17612

NATIONAL LIBRARY
OTTAWA

CANADA

BIBLIOTHÈQUE NATIONALE
OTTAWA

NAME OF AUTHOR.....RAYMOND MAKOWECKI.....

TITLE OF THESIS.....THE TROPHY PIKE, ESOX LUCIUS, OF SEIBERT LAKE...

.....

UNIVERSITY.....ALBERTA.....

DEGREE FOR WHICH THESIS WAS PRESENTED....M.Sc.....

YEAR THIS DEGREE GRANTED.....1973.....

Permission is hereby granted to THE NATIONAL LIBRARY OF CANADA to microfilm this thesis and to lend or sell copies of the film.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

(Signed)...Ray Makowecki

PERMANENT ADDRESS:

...8716-153 Street

...EDMONTON, ALBERTA

...T5R 1N9.....

DATED...October 3.....1973

NL-91 (10-68)

THE UNIVERSITY OF ALBERTA

THE TROPHY PIKE, *Esox lucius*, OF SEIBERT LAKE

by

© RAYMOND MAKOWECKI

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

DEPARTMENT OF ZOOLOGY

EDMONTON, ALBERTA

FALL, 1973

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled The Trophy Pike, *Esox lucius*, of Seibert Lake submitted by Raymond Makowecki in partial fulfilment of the requirements for the degree of Master of Science.

Joseph S. Nelson
Supervisor

Donald N. Gillup

Ross B.J. Macnet

Date September 26, 1973

ABSTRACT

Seibert Lake has a history of very large northern pike. Because of this characteristic, it was designated a trophy lake in 1970. The purpose of the study was to determine reasons for the pronounced growth of pike and to determine methods of managing the fishery for the future.

Seibert Lake is well exposed to prevailing winds, thus the lake does not stratify in terms of temperature and oxygen. Forty per cent of the lake surface area is in the littoral region. The littoral region has a much greater biomass of bottom fauna than that in the profundal region (4:1). In comparison with other lakes of similar latitude, the Seibert bottom fauna is by mass less abundant. A sand-gravel bottom type forms 75 per cent of the substrate in the littoral region

The lake whitefish (*Coregonus clupeaformis*) population appears to be large in number but relatively small in size (few fish exceeding two pounds). The whitefish are distributed to a large extent in the littoral region and this is indicative of their diet and of their position in the trophic structure.

The walleye *(Stizostedion vitreum)* population like the whitefish population seems to be large in number but relatively small in size. Again like the whitefish the walleye converge upon the littoral region for their food supply; thus their diet overlaps with that of the whitefish. The usual fish diet of walleye is not the case in Seibert since few forage fish appear to be present.

The pike(*Esox lucius*)population is small in number but with relatively large-sized individuals. Small pike have diets similar to walleye and whitefish and show a rather inhibited growth rate to the age

of five. Sexual dimorphism is very pronounced, thus males continue to grow slowly. The factors most responsible for pike growth include: low pike production, certain vegetative types and their associations and a whitefish population which is available, appropriate, abundant and desirable as the major food item for large pike.

A strong positive correlation exists between pike abundance and vegetation quality. The most important vegetation types for large pike include *Nuphar variegatum*, *Potamogeton praelongus* and *Potamogeton natans*. The prime areas include these vegetation types plus others; thus a high degree of diversity. Pike abundance correlates poorly ($r = +.24$) with abundance of bottom fauna.

Greater than 60 per cent of the pike come from two areas and 90 per cent of the large pike come from these areas which are of prime habitat (S_5 and S_{13}). Most pike show little movement (78 percent) but those that move seem to move from poor habitat to better habitat.

With increasing interest in the trophy lakes a greater pressure is placed upon the relatively small numbers of trophy pike. To maintain the trophy fishery for the future, restrictions must be placed upon the techniques used in capturing fish so as to reduce mortality of fish being released and regulations must be instituted to reduce total numbers of trophy pike being removed.

Certain lakes have characteristics which allow for good growth of fish. Because of the unique characteristics of any biological system, lakes must be managed on an individual basis. It is suggested that the trophy lake concept is a worthwhile idea and should be managed accordingly.

ACKNOWLEDGEMENTS

This study was supported by the Alberta Fish and Wildlife Division of the Department of Lands and Forests and the University of Alberta. I am particularly appreciative of the financial support provided mainly by the Alberta Fish and Wildlife Division.

Expression of thanks is due to a great number of people who provided essential assistance in the field. I thank R. Potts and D. Brown for their assistance in 1971; to D. Brown and E. Johansen in 1972. I owe thanks to people who assisted in the tagging operation; Mr. D. Makowecki, Mr. M. Spady and Mr. D. Green. I am most sincerely owing to my brother Clarence for the numerous hours he spent in all aspects of the field work and in reviewing this manuscript.

I thank Mr. Dale Allen for his assistance in the identification of aquatic plants and I am grateful to Mr. Stan Eliuk for his assistance in the completion of this manuscript.

To many employees of the Alberta Fish and Wildlife Division but in particular to Mr. K. Zelt and Dr. B. Bidgood I express gratitude for their advice and assistance.

To Ms. Linda Thirsk and Ms. Louise Olshewski for their secretarial work and general assistance I thank you.

My most sincere thanks are due to Dr. M. J. Paetz for his guidance, advice, criticisms of the manuscript and to Dr. J. S. Nelson for his guidance and supervision and for critically reviewing this manuscript.

To my wife, Margaret, and my family for the sacrifices which they made, I expecially thank.

TABLE OF CONTENTS

ABSTRACT v

ACKNOWLEDGEMENTS vii

LIST OF TABLES xii

LIST OF FIGURES xiv

LIST OF PHOTOGRAPHS xvi

I INTRODUCTION 1

II DESCRIPTION OF THE STUDY AREA 3

LOCATION 3

DRAINAGE AND LAKE DESCRIPTION 3

SOILS AND SURROUNDING VEGETATION 6

CLIMATE 6

III MATERIALS AND METHODS 9

ORGANIZATION 9

ANGLER SURVEY 9

FISH MEASUREMENTS AND ANALYSIS 11

GENERAL LIMNOLOGY 12

(a) Physico-chemical 12

(b) Biological 14

MICROENVIRONMENT DETERMINATION 14

(a) Bottom fauna 15

(b) Vegetation 15

FISH SAMPLING 15

TAGGING 18

IV RESULTS..... 23
A. GENERAL LIMNOLOGY..... 23
PHYSICAL AND CHEMICAL CHARACTERISTICS..... 23
PLANKTON..... 27
BOTTOM TYPES AND BOTTOM FAUNA..... 27
B. FISHES..... 34
LAKE WHITEFISH..... 38
Growth..... 38
Abundance of Age Groups..... 42
Food of Lake Whitefish..... 42
Incidence of Cysts..... 45
Angling and Commercial Fishing..... 45
WALLEYE..... 49
Growth..... 49
Abundance of Age Classes..... 54
Spawning and Age of Maturity..... 54
Distribution of Walleye in Seibert Lake..... 56
Food of Walleye..... 61
NORTHERN PIKE..... 66
Growth..... 66
Abundance of Age Classes..... 71
Distribution of Northern Pike..... 71
Age Structure of Pike Captured in Different Lake Zones..... 75
Maturation and Spawning..... 75
Food of Pike..... 82

Lake Whitefish as a Major Food Item..... 87

Tagged Northern Pike..... 89

(a) Age Class Distribution and Size..... 89

(b) Distribution of Tagged Pike and Characteristics of Pike in Different Lake Zones..... 92

Pike Population Size..... 99

Movements..... 106

C. MICROENVIRONMENT EXAMINATION..... 108

BOTTOM FAUNA..... 108

Bottom Type..... 108

Shoreline Vegetation..... 110

Bottom Fauna..... 110

VEGETATION..... 118

D. PUBLIC UTILIZATION..... 132

(a) Questionnaire..... 132

(b) Creel Census..... 134

(c) Three Year Comparison of the Trophy Lake Concept... 138

V DISCUSSION..... 141

LIMNOLOGICAL ASPECTS..... 141

FISHES..... 145

Lake Whitefish..... 145

Walleye..... 148

Northern Pike..... 150

INTERACTION OF FISH POPULATIONS..... 159

HABITAT QUALITY IN RELATION TO CHARACTERISTICS OF THE PIKE POPULATION..... 168

FACTORS YIELDING "TROPHY PIKE" AT SEIBERT LAKE..... 174

PUBLIC UTILIZATION AND SUGGESTED MANAGEMENT..... 179

VI CONCLUSIONS..... 182

VII LITERATURE REVIEWED..... 184

VIII APPENDICES..... 196

I ANGLERS INFORMATION SHEET..... 196

II (A) TROPHY ANGLER QUESTIONNAIRE-ACCOMPANYING LETTER..... 197

(B) QUESTIONNAIRE..... 198

III (A) TAGGED PIKE 1971 (DATE,SIZE,AGE, TAG NUMBER AND LOCATION)..... 199

(B) TAGGED PIKE 1972 (DATE,SIZE,AGE, TAG NUMBER AND LOCATION)..... 213

IV CHEMICAL ANALYSIS OF SEIBERT LAKE WATER..... 227

V LIST OF THE GENERA OF BOTTOM FAUNA..... 228

VI LAKE WHITEFISH: VARIATION IN FORK LENGTHS AND WEIGHTS OF AGE CLASSES..... 229

VII STOMACH CONTENTS OF LAKE WHITEFISH..... 230

VIII WALLEYE: VARIATION IN FORK LENGTHS..... 231

IX WALLEYE: VARIATION IN WEIGHTS..... 232

X WALLEYE STOMACH CONTENTS..... 233

XI NORTHERN PIKE: VARIATION IN FORK LENGTHS..... 235

XII NORTHERN PIKE: VARIATION IN WEIGHTS..... 236

XIII PIKE CAUGHT IN 1971 AND 1972..... 237

XIV VARIATION IN FORK LENGTH OF TAGGED PIKE..... 238

XV LIST OF BOTTOM FAUNA FOUND AT THE 10 ft. (3.0m.) DEPTH..... 239

LIST OF TABLES

TABLE 1. Meterological readings: temperature and precipitation... 7

2. Morphometric parameters of Seibert Lake..... 24

3. Oxygen and temperature readings at Seibert Lake..... 26

4. Zooplankton counts through 1,932 cu. in. (34,486 cm^3) of water in the form of a 10 ft. (3 m.) vertical haul.... 28

5. Bottom types at six measured depths..... 29

6. Abundance of bottom fauna of various depths..... 32

7. Major bottom fauna..... 33

8. Commercial fish records from Seibert Lake..... 36

9. Incidence of *Triaenophorus crassus* in lake whitefish..... 47

10. Walleye maturity..... 59

11. Angler caught walleye 1971 and 1972..... 60

12. Statistical differences between mean lengths of male female northern pike..... 72

13. Size and age of northern pike in different areas of the lake..... 77

14. Age of maturity of northern pike in Seibert Lake..... 80

15. Northern pike stomach contents..... 84

16. Size of pike eating certain food items..... 85

17. Locational differences of tagged northern pike..... 94

18. Statistical differences in growth of pike from different zones of Seibert Lake..... 98

19. Population size of pike at Seibert Lake..... 101

20. Populations in different lake zones..... 102

21. Numbers of trophy pike in Seibert Lake..... 104

22. Return rate (explotation rate) of tagged pike of various age classes..... 105

23. Movements of pike from tagged returns..... 107

24. Bottom types at the ten foot depth..... 109

25. Shoreline vegetation of Selbert Lake..... 113

26. Bottom fauna in lake zones at the 10 foot (3m.) depth.... 115

27. Vegetation types from Selbert Lake..... 120

28. Vegetation sampling results..... 121

29. Per cent cover of submergent vegetation at the ten foot (3 m.) depth..... 123

30. Questionnare results..... 133

31. 1971 Creel Census..... 135

32. 1972 Creel Census..... 136

33. Angler success..... 137

34. Three year comparison of trophy lake interest..... 139

35. Place of residence of trophy lake licencees..... 140

36. Mineral analyses of water in eight central Alberta lakes. 142

37. Abundance and volume of bottom fauna in seven Alberta lakes..... 144

38. Comparison of growth of lake whitefish from various lakes in Canada..... 146

39. Comparison of growth of walleye from five lakes in Canada 149

40. Comparison of growth of northern pike in nine lakes from various parts of the world..... 151

41. Comparison of major food items of northern pike from six lakes..... 165

42. Characteristics of lake zones in Selbert Lake..... 169

43. Correlation of pike abundance to various habitat factors. 170

44. Factors which best select for northern pike..... 173

45. Result of alteration in factors responsible for pike growth..... 178

46. Selbert Lake zonal situations with respect to northern pike..... 180

LIST OF FIGURES

FIGURE 1. Location of Seibert Lake and access..... 4

2. Drainage basin and surrounding lakes..... 5

3. Randomly selected lake zones at Seibert Lake..... 10

4. Limnological stations at Seibert Lake (Oxygen and temperature readings, light penetration, plankton samples and bottom samples)..... 13

5. Bottom sample locations..... 16

6. Gill net sets and seining locations..... 19

7. Contour map of Seibert Lake..... 25

8. Bottom fauna from all depths..... 31

9. Lake whitefish: age-length relationship..... 39

10. Lake whitefish: age-weight relationship..... 40

11. Lake whitefish: length-weight relationship..... 41

12. Numbers of whitefish of different age classes..... 43

13. Lake whitefish-stomach contents..... 44

14. Walleye: age-length relationship..... 50

15. Walleye: age-weight relationship..... 51

16. Walleye: length-weight relationship..... 52

17. Walleye: frequency of different age classes..... 55

18. (a) Walleye: peak spawning 1971..... 57

(b) Walleye: peak spawning 1972..... 58

19. Walleye locational abundance..... 62

20. Walleye stomach contents: number of organisms found in walleye..... 63

21. Walleye stomach contents: per cent occurrence of food items..... 64

22. Northern pike: age-length relationship..... 67

23. Northern pike: age-weight relationship..... 68

24. Northern pike: length-weight relationship..... 70

25. Northern pike: frequency of age classes..... 73

26. Northern pike: locational abundance..... 74

27. Lake zones where pike are retained and released..... 76

28. Mean length and age of pike in different parts of the lake..... 78

29. Pike stomach contents..... 83

30. Northern pike: size of pike eating certain fish items.. 86

31. Stomach contents of pike: food item lake whitefish..... 88

32. Numbers of tagged pike of particular age classes..... 91

33. Tagged pike: age-length relationship..... 93

34. Northern pike: numbers of tagged pike in different areas..... 95

35. Tagged pike: mean ages and lengths in the 14 lake zones..... 96

36. Emergent and floating vegetation types..... 111

37. Bottom fauna at the ten foot depth in different areas of the lake..... 117

38. Bottom fauna at the ten foot depth..... 119

39. Vegetation: per cent vegetation in different lake zones 124

40. Vegetation diversity: habitat quality..... 125

41. Vegetation diversity: habitat quality..... 125

42. Lake vegetation: per cent of different types of vegetation..... 126

43. Pike habitat quality..... 131

44. Differential growth of pike from different lake zones... 158

45. Comparison of the diets of lake whitefish and walleye found in Seibert Lake..... 161

46. Trophic structure found in Seibert Lake..... 164

LIST OF PHOTOGRAPHS

PHOTOGRAPHS

1. Modified rake used in vegetation sampling..... 17
2. Rake with vegetation..... 17
3. Trough-like apparatus..... 20
4. Applicator and tags used in tagging operation..... 20
5. Position of tag on a northern pike..... 22
6. Channel leading into S_{13} bay..... 35
7. *Triaenophorus crassus* in lake whitefish..... 46
8. S_{13} bay - a spawning area..... 81
9. Northern pike with lake whitefish in the stomach... 90
10. Digestion of lake whitefish found in pike stomachs. 90
11. *Scirpus*, the water bulrush..... 112
12. *Nuphar*, the yellow pond lily..... 112
13. Typical barren shoreline..... 114
14. *Nuphar variegatum* - yellow pond lily..... 130
15. Diversified habitat..... 130

INTRODUCTION

In the management of sport fisheries for the future there is an outlook towards the preservation of certain lakes for the largeness of their fish. The idea that in the future our children's children will be able to capture a trophy fish as we have done is encompassed within the philosophy of the trophy lake concept. If initially we have a lake with the history of relatively large numbers of "large fish" then there are methods of managing the fishery so as to best select for the production of these fish.

With these basic ideas in the minds of Alberta's sportsmen and with some communication with the chief fishery biologist of the Alberta Fish and Wildlife Division, Dr. M.J. Paetz, the ideas became practice. In April of 1970 the Alberta Fish and Wildlife Division undertook a program of setting aside seven Alberta lakes as trophy lakes. The lakes included God's (Twp. 90, Rge. 2, W5th M), May (Twp. 66, Rge. 3, W4th M), Seibert (Twp. 66, Rge. 9, W4th M), Andrew (Twp. 125, Rge. 1, W4th M), Gardiner (Twp. 98, Rge. 16, W4th M), Namur (Twp. 97, Rge. 17, W4th M), and Winefred (Twp. 75, Rge. 4, W4th M).

The species of fish being selectively managed in these lakes are northern pike *(Esox lucius)* and/or walleye *(Stizostedion vitreum)*. Two regulations were instituted for the purpose of managing these trophy lakes. Firstly, the requirement of a special trophy lake licence was instituted to discourage those who were not greatly concerned about catching a trophy. Secondly, a reduction in the limit of the trophy species so as to reduce the numbers being removed and a reduction in the limit of other sport fishes so as to discourage those visiting the lake for purposes other than the trophy species were involved.

With the increasing pressures placed upon all aspects of outdoor recreation, it becomes increasingly difficult to maintain the large fish desired from a trophy lake. The east-central part of Alberta is an area of tremendous recreational potential. The area contains many lakes which produce pike, perch, walleye and whitefish. Seibert Lake is found in this area of Alberta and because of the largeness of the northern pike, it was selected as one of the trophy lakes. The increased number of four-wheel drive vehicles along with the increased improvement of the road has made Seibert the most popular of the seven trophy lakes.

The objectives of this study are three-fold:

(a) To determine the public utilization of a trophy fishery resource as well as to possibly forecast the future of this resource.

(b) To describe the general limnology of Seibert Lake in an attempt to determine reasons for the presence of large northern pike.

(c) To determine certain aspects of the life history of northern pike. These aspects will include such parameters as growth, trophic structure, habitat quality and population interactions.

Encompassed within these objectives is the attempt to determine the size of the northern pike population and the interaction of this population with other sport fish populations such as the walleye and the lake whitefish.

In a different perspective the purpose of this study is to determine the various factors (including the human factor) which affect the trophy fishery resource and then to suggest management practices which will best maintain or enhance this resource.

DESCRIPTION OF THE STUDY AREA

Location

Seibert Lake is situated at latitude 54° 45' N and longitude 111° 20' W. It lies 46 miles (74.1 km) north of St. Paul, Alberta and 180 miles (289.8 km) northeast of Edmonton, Alberta (Figure 1).

Access and angling pressure are highly dependent upon weather conditions. A 14 mile (22.5 km) forestry road from Truman is a dry weather road; therefore, most of the visitors to the lake use four-wheel drive vehicles (Bishop 1971 Unpubl. Report). The single access point on the southeast shore allows for a controlled evaluation of public utilization and angler success.

Drainage and Lake Description

The lake lies at an altitude of 2,038 feet (690 m) above sea level. Six intermittent streams enter the lake. The outflowing stream at the south end of the lake drains into the Sand River. The Sand River also receives a creek from Spencer Lake and also receives Punk Creek which drains Touchwood and Pinehurst Lakes (Figure 2). The Sand River then joins the Beaver River which flows east to become part of the Churchill River system which drains into the Hudson Bay. The drainage basin centered by the lake covers an area of approximately 27 square miles (69.9 km^2). The actual drainage basin is extremely confusing due to the fact that Seibert Lake has numerous underground springs which may connect it to either or both Touchwood and Spencer Lakes.

Seibert Lake is seven miles (11.3 km) along a northwest-southeast axis and three and one third miles (5.3 km) along a southwest-northeast axis.

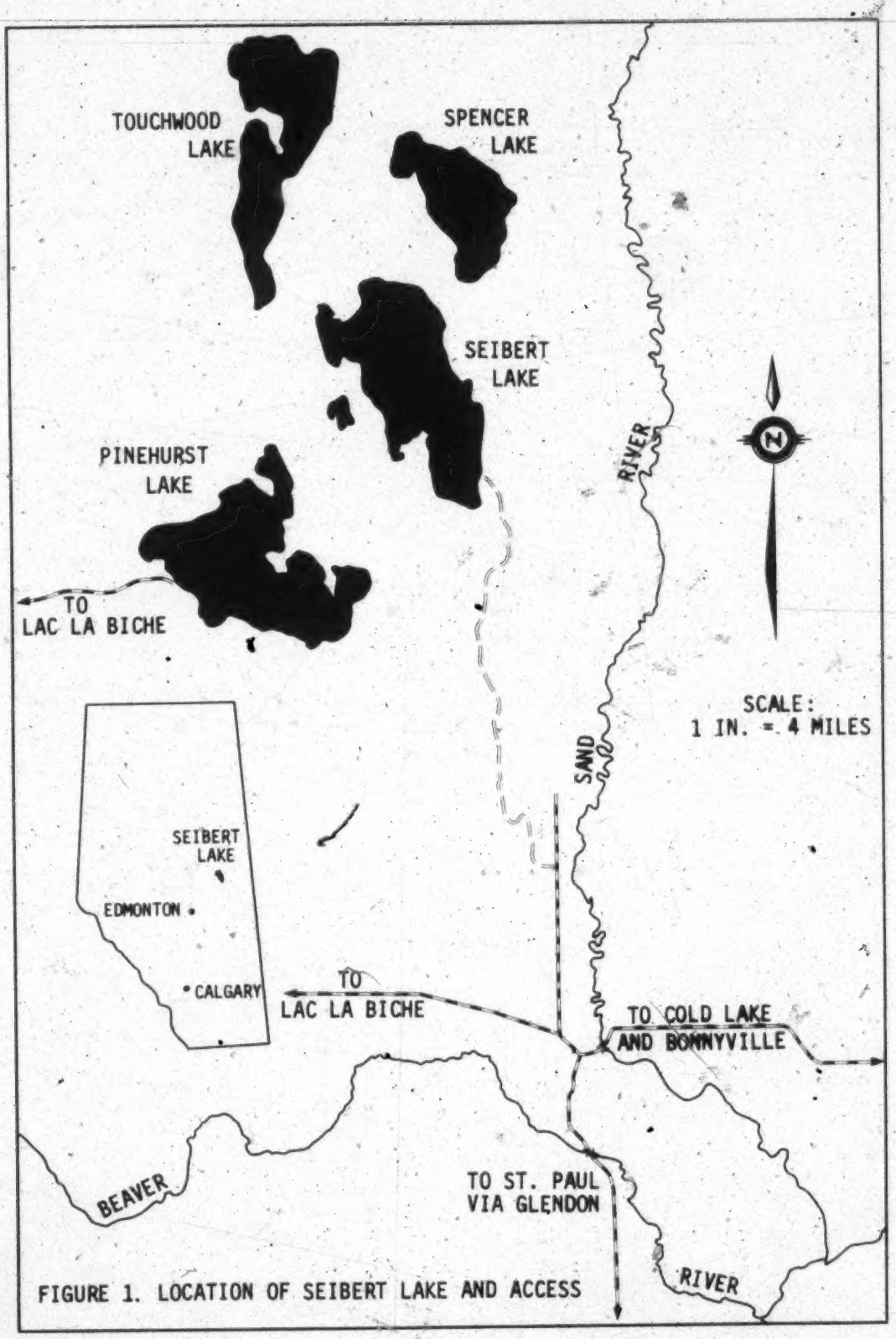


FIGURE 1. LOCATION OF SEIBERT LAKE AND ACCESS

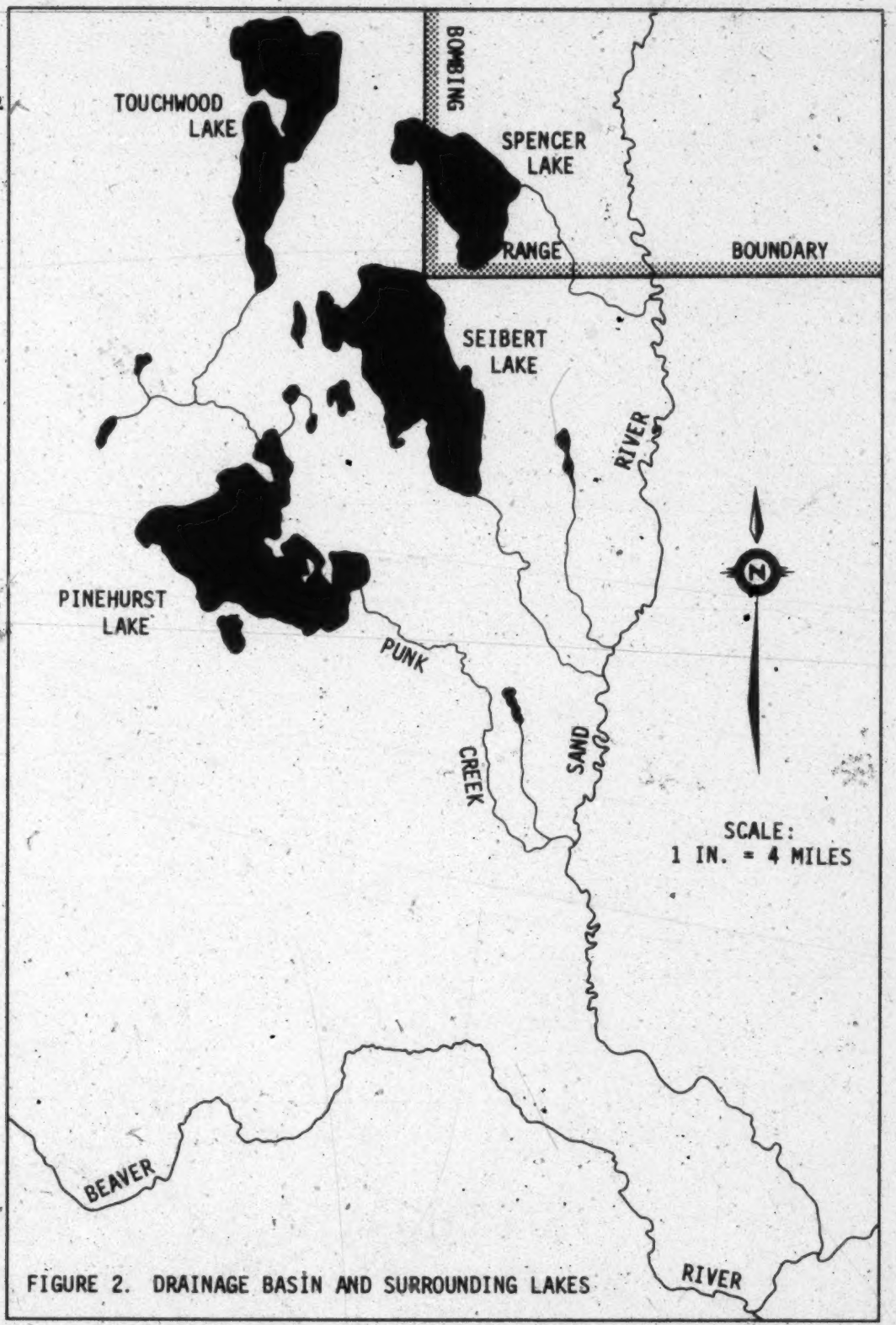


FIGURE 2. DRAINAGE BASIN AND SURROUNDING LAKES

It covers an area of 13.6 square miles (35.2 km^2), or 8,704 acres (3,482 hectares). With low lying areas to the north, the lake is well exposed to the prevailing winds. It has a maximum depth of 36 feet (11 meters) and a total capacity of 173,210 acre feet (2.1 x $10^8 m^3$).

Soils and Surrounding Vegetation

The area surrounding Seibert Lake has podsolic, grey-wooded soil, low in fertility and low in organic matter. The actual soil type of the land on the west and south shores of Seibert is a clay loam. Sand is the type of soil on the north and east sides of Seibert.

The bedrock of the area is composed of shales and sandstones of the Late Cretaceous age. The area is characterized by a north-south directional, glacial spillway which eventually swings to an east-west direction (Lindsay et al., 1963 Preliminary Soil Survey, Res. Coun. of Alberta).

Mixed boreal forest surrounds the lake but on the west and south shores a predominance of aspen poplar occur. Parts of the north and east shores have quite large white spruce. Occasional low lying areas with willows and birch may be found (Forestry, Sand River 73L, Can. Land Inventory).

Climate

Table 1 shows the normal temperatures and precipitation from Lac La Biche (Meterological Published Normals), the nearest meterological station. The month of July is characterized by the warmest temperatures and the greatest precipitation. The mean annual daily temperature is 34.2° F (1.2° C) and the total annual precipitation is 17.85 inches (45.3 cm).

TABLE 1. Meterological Readings: Temperature and Precipitation (Readings taken at Lac La Biche-1958-1971)

Month	Mean Daily Temperature (°F)	Precipitation (inches)
January	1.4	1.03
February	6.7	.76
March	18.1	.87
April	36.2	1.02
May	50.1	1.36
June	57.4	2.64
July	62.3	2.83
August	59.5	2.74
September	50.0	1.80
October	39.4	.78
November	21.2	.97
December	8.5	1.05
Mean Annual Temperature	34.2	Total Annual Precipitation 17.85

The number of frost free days at Seibert Lake is approximately 85. The ice covers the lake for five to six months starting in mid-November and breaking up in early to mid-May.

At the point of access the Alberta Forest Service has constructed a campsite and a government cabin. With the exception of an old lumber mill at the south end of the lake and a few trapper cabins to the north, no other buildings exist in the area. Seibert Lake is in the green zone and no agricultural practices occur within its drainage basin.

MATERIALS AND METHODS

Organization

The study was initiated in January of 1971 and terminated in July of 1973. The work was essentially done in the spring-summer periods and the following is a time breakdown of the activities involved during the study:

(a) May-September 1971 and 1972, creel census and collection of information from fish.

(b) May-June 1973, creel census to receive tagged fish.

(c) July-August 1971 and 1972, limnological survey, habitat analysis and tagging operation.

Occasional visits were made during the fall and winter periods to assess public utilization but the number of trips were limited because of the difficulties encountered with snow. The road is not snowplowed.

A basic part of the study related to proper communication with anglers as to the location in which fish were being caught and either retained or released. The locational aspect was followed throughout the limnological survey, habitat analysis and tagging operation and thus acted as a unifying element. The lake was divided into 14 shoreline areas which would best allow for accurate communication with anglers (Figure 3). These areas, selected at random, will be referred to as lake zones throughout this manuscript.

Angler Survey

All parties visiting the lake were given a pre-angling interview to inform them about the type of information desired and to make them aware of the presence of tagged fish. Each party was given a contour map of the lake so as they could point out or mark their

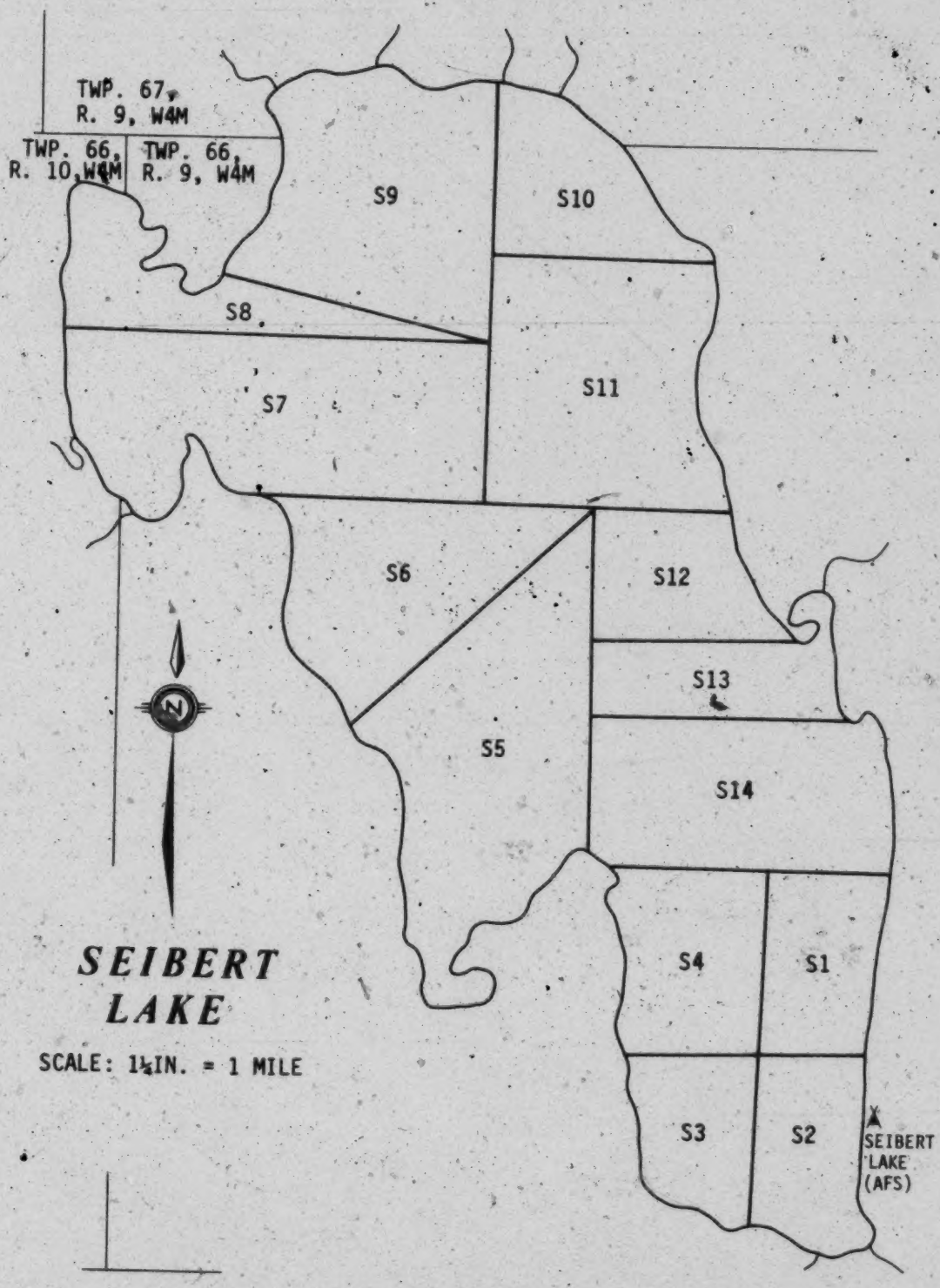


FIGURE 3. SELECTED LAKE ZONES AT SEIBERT LAKE

angling locations. Anglers were asked to note the numbers of fish being caught. This included the numbers released as well as those retained. Anglers were asked to return any tagged fish which were caught.

Various signs were placed in the Seibert Lake campground to indicate that tagged fish were present in the lake. These signs indicated the information desired and where the information could be sent. Thus some information has come from anglers by way of telephone or by mail.

The post-angling interview involved a series of questions (see Appendix I). Questions pertaining to angling locations, number and type of fish released and number of hours angled formed the basis of this interview. Most of the fish caught by anglers were sampled.

A questionnaire and explanatory letter (see Appendix II (A) and (B)) was sent to all trophy lake licencees after the 1971-72 fiscal year to determine angler seasonal activities, numbers utilizing the trophy fishery resource and which trophy lakes were being utilized.

Fish Measurements and Analysis

All species of sport fish were sampled. The samples came mainly from angler catches but some also came from gill netting. The information collected from each fish included: date, species, fork length, wet weight, sex, maturity, scales, stomach contents and location of capture. A number of heads from northern pike and walleye were also collected and later frozen and in some cases looked at for verification of age.

Fish were aged by the scale method. Cellulose acetate slides were melted together enclosing the scales and the scales were then examined under a Bausch and Lomb Tri-Simplex Microprojector.

Stomach contents were preserved in 5 per cent formaldehyde and later identified, counted and weighed. In many cases the stomach sample consisted of a large fish and wherever possible scales, lengths and weights were taken.

The fishes which were of major concern were northern pike, walleye and lake whitefish. Occasional sampling of perch, burbots and suckers did occur.

General Limnology

Data were collected during the month of July 1971 in 14 stations which coincide with the 14 lake zones. Each station had sampling points at the following depths: 5 foot (1.5 m), 10 foot (3.0 m), 15 foot (4.5 m), 20 foot (6.0 m), 25 foot (7.5 m) and 30 foot (9.0 m) (see Figure 4).

(a) Physico-chemical

At each limnological station the following procedure was carried out:

(i) Dissolved oxygen levels were determined using the Winkler Method. These measurements were taken at every 5 foot (1.5 m) level to a maximum depth in each of the limnological stations. The deepest sampling point within the zone was used. Water samples were obtained using a 1200 ml Kemmerer sampler.

(ii) Water temperatures were taken in conjunction with oxygen determination. Again the deepest sampling point within the zone was used and temperatures were taken every 5 feet (1.5 m) to the maximum.

(iii) Light penetration readings were taken at the start of each sampling day and at the completion of the particular

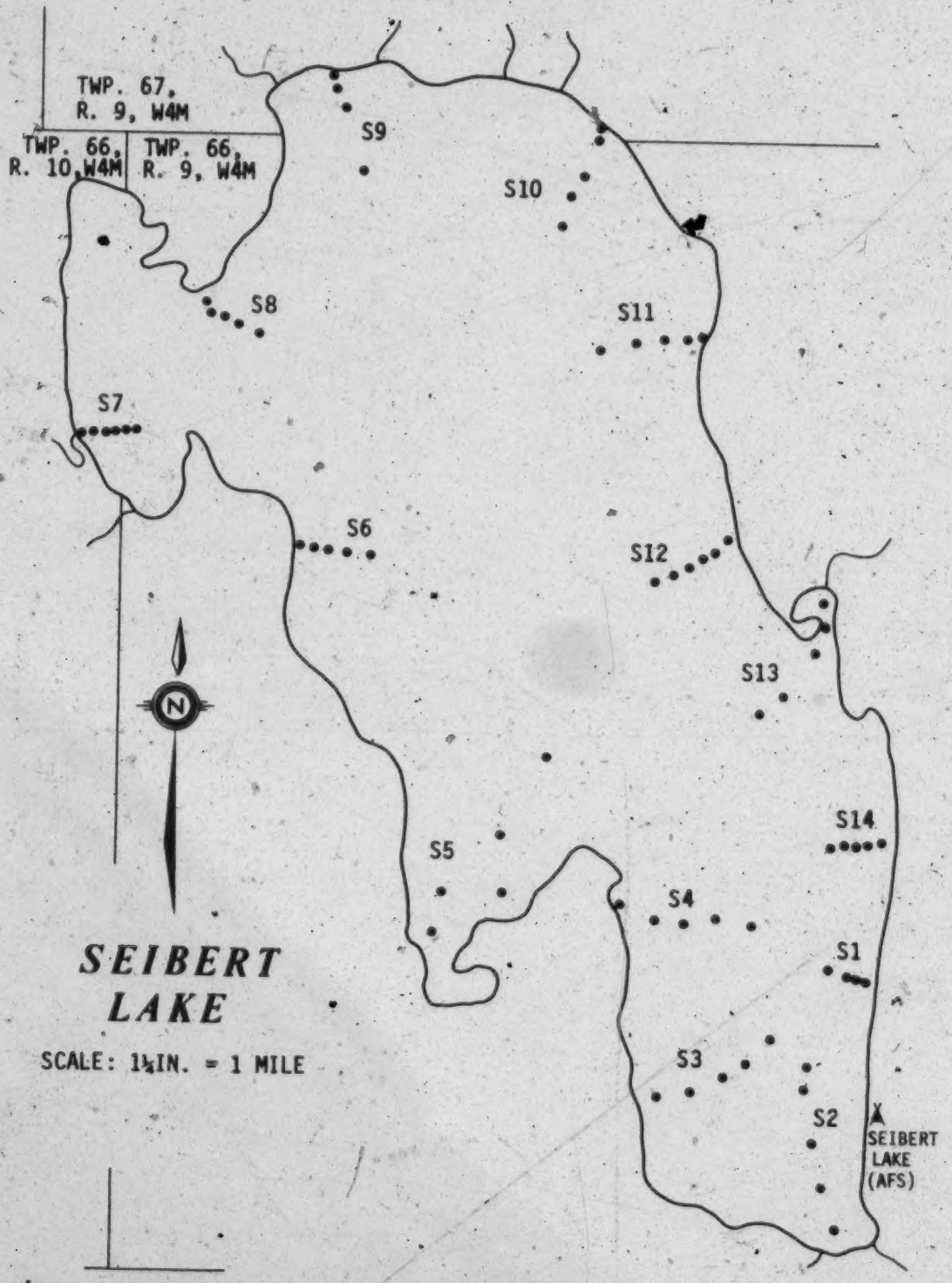


FIGURE 4. LIMNOLOGICAL STATIONS AT SEIBERT LAKE. (OXYGEN AND TEMPERATURE READINGS, LIGHT PENETRATION, PLANKTON SAMPLES, AND BOTTOM SAMPLES)

limnological station. An 8 inch (20 cm) secchi disc was used.

(iv) Water samples were collected for chemical analysis by the Pollution Control Laboratory of the Alberta Department of the Environment.

(b) Biological

(i) Plankton samples were collected using a "Wisconsin" style net with a diameter of 4.8 inches (12 cm). At the deepest sampling spot in each lake zone a 10 foot (3.0 m) vertical haul was taken and another at the 12 foot (3.6 cm) depth. The plankton was preserved in 50 per cent ethyl alcohol.

Zooplankton was counted using a sectioned water glass and glycerin to stabalize the plankton while counting.

(ii) Bottom samples were collected with a 6 inch square (231.0 cm^2) Ekman dredge. Each sample consisted of two dredges one-half square foot (462 cm^2). At each of the 14 locations, samples were taken at every 5 foot depth to the maximum depth. Organisms were removed from the substrate with the aid of a screen bottom bucket (36 meshes per inch or 14 meshes per cm). The organisms from a sample (one-half square foot) were placed in 10 per cent formaldehyde for later analysis.

Noted at each sampling point was the bottom type (substrate) and the presence or absence of vegetation.

Bottom fauna were later identified, counted, weighed and described volumetrically.

Microenvironment Determination

To further describe the lake in terms of microhabitat

differences, the following sampling techniques were carried out in July-August periods of 1971 and 1972.

(a) Bottom fauna at the 10 foot depth.

On a map of the lake 72 sampling locations were marked (see Figure 5) and at each station the following activities were performed.

(i) bottom sample, two dredges forming one-half square foot (462 cm^2) using a 6 inch square (231.0 cm^2) Ekman dredge.

(ii) shoreline vegetation, emergent or floating, was noted.

(iii) bottom type was described.

(iv) type of submergent aquatic vegetation present was noted.

The bottom fauna was preserved in 10 per cent formaldehyde and later identified, counted, weighed and described volumetrically.

(b) Vegetation analysis at 8-10 feet (2.4-3.0 m).

On a map of the lake 104 points were randomly marked and at an 8-10 foot depth (2.4-3.0 m) samples were taken. The sampling procedure for each of the 104 points (anchored spots) was to take 4 hauls one at each corner of the boat. A modified rake (Photographs 1 and 2) was used in the collection of a total of 364 samples. The vegetation types were identified for each sample. Samples of each vegetation type were preserved in 10 per cent formaldehyde.

Fish Sampling

Seining was carried out numerous times at various locations for the purpose of identifying the smaller fishes found in the lake. Also, young of the year northern pike were desired for information on growth.

The use of gill nets was limited but in 1971 a number of sets were made for the purpose of capturing and subsequently tagging northern pike. When other species were taken, they were sampled. In August of

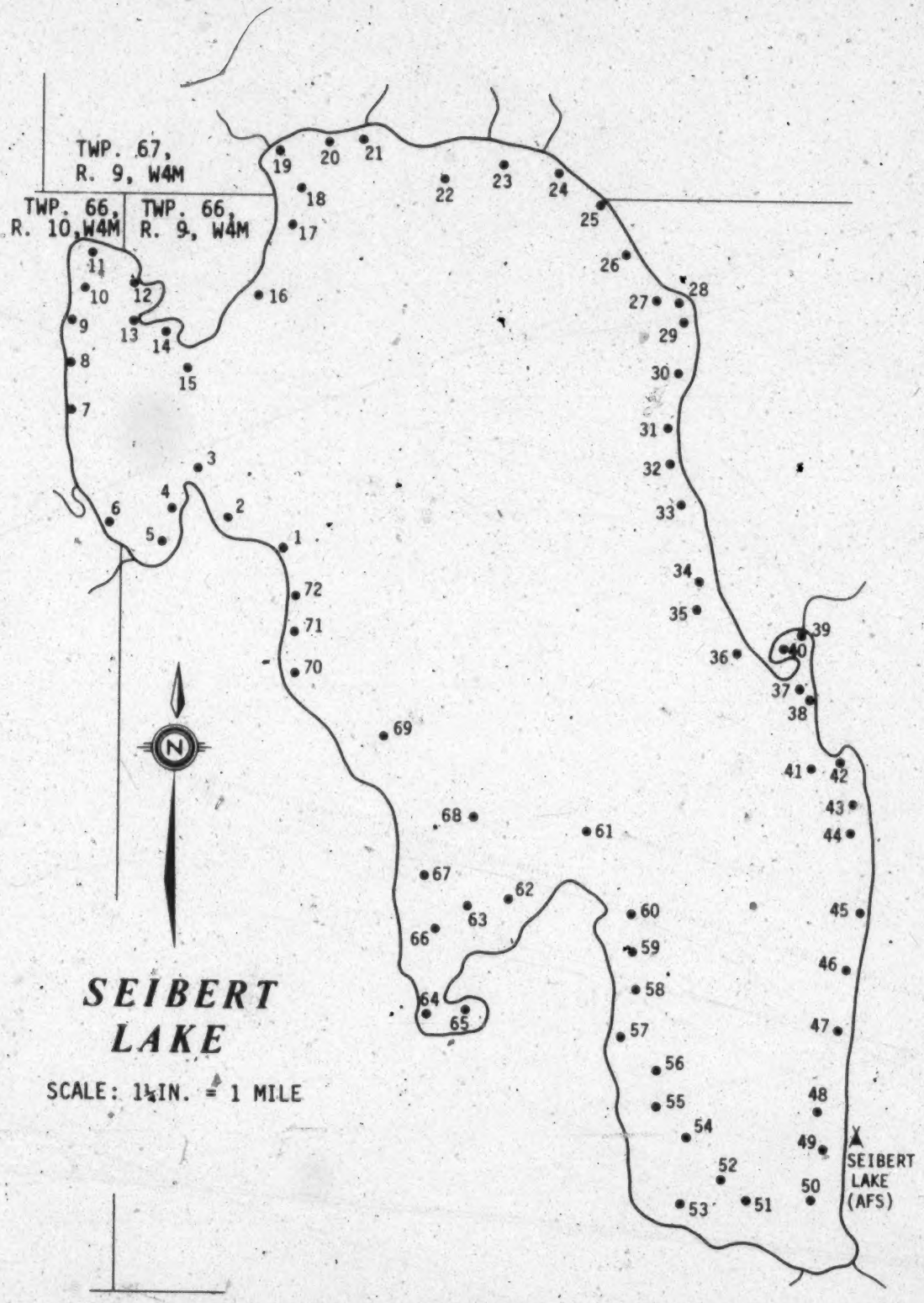
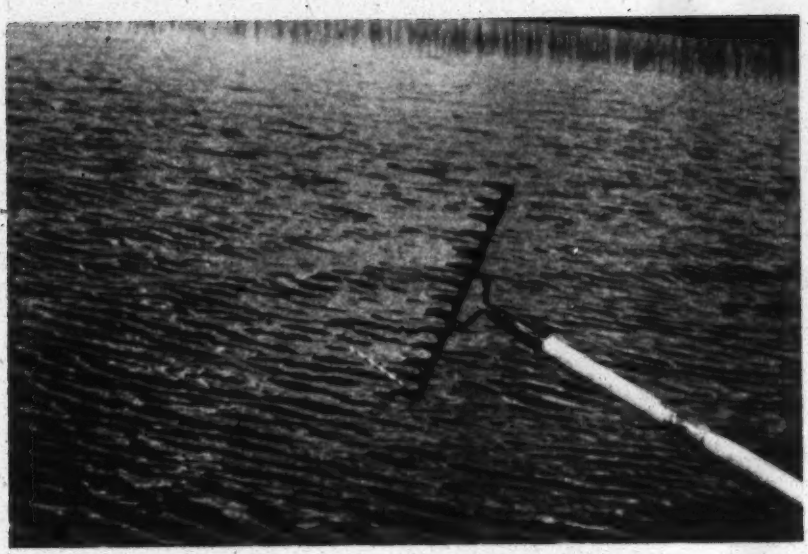


FIGURE 5. BOTTOM SAMPLE LOCATIONS (ALL SAMPLES TAKEN AT A DEPTH OF 10 FEET (3 METERS).)



Photographs 1 and 2. Modified rake used in vegetation sampling.

1972 a test gang (i.e. 1½", 2½", 3½", 4½" and 5½" stretched mesh) was used for the purpose of determining fish species present in Seibert and also to obtain a larger lake whitefish sample.

Figure 6 shows the location of seining and gill net sets.

Rotenone was used to collect fish.

Angler catches provided the bulk of material for age and growth data of northern pike and walleye.

Tagging

In order to determine population sizes, distribution, movements and growth of northern pike, a tagging operation started in July 1971. Three methods were used in attempting to capture fish for the purpose of tagging:

(a) running gill nets of 3½ inch, 5 inch and 5½ inch mesh size (lifting gill nets at half hour intervals)

(b) seining

(c) angling with non-barbed hooks

After a fish was captured it was placed on a trough-like structure (Photograph 3), fork length was measured, scales from the region of tag insertion were removed and the dart was inserted. The placement of the dart was anterior to the dorsal fin and dorsal to the lateral line; it was pushed in under the skin between the flesh and the skin, a quarter turn to the applicator and removal of the applicator left the dart embedded. The needle type applicator and 70 per cent ethyl alcohol (disinfectant) were used along with numbered double barbed nylon dart 5/8 inch shaft, #20 vinyl tubing tags (Photograph 4). The dart tags were obtained from Floy Tag and Manufacturing, Inc., Seattle.

Information noted included date, fork length, age (scales),

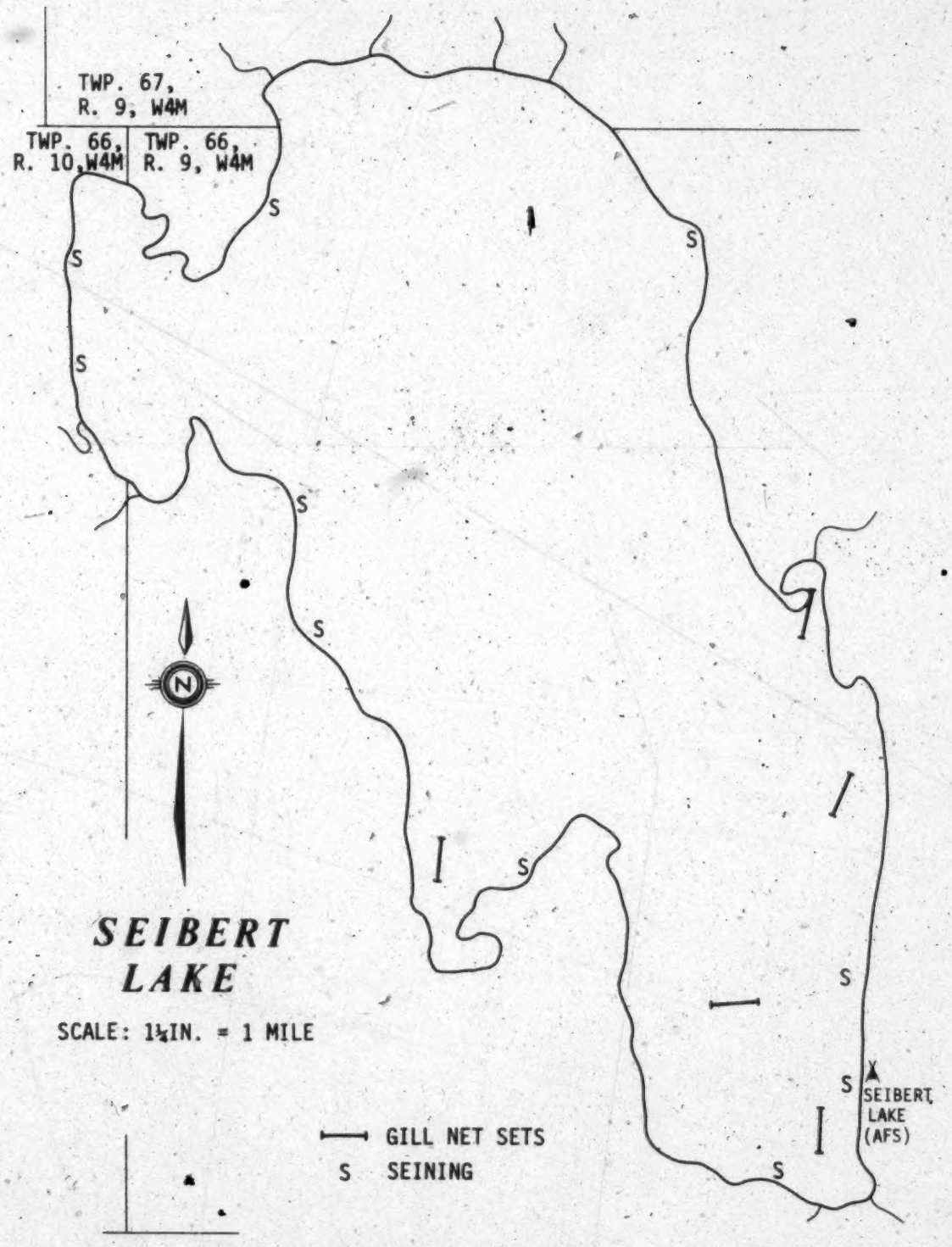
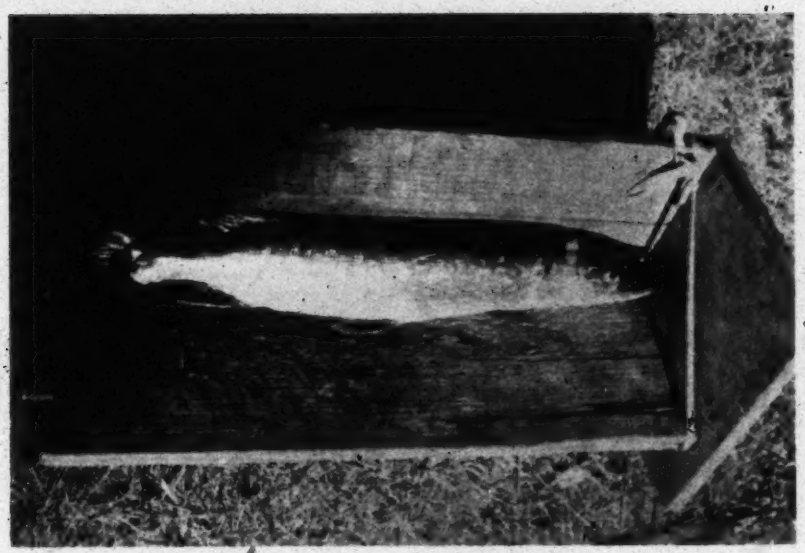
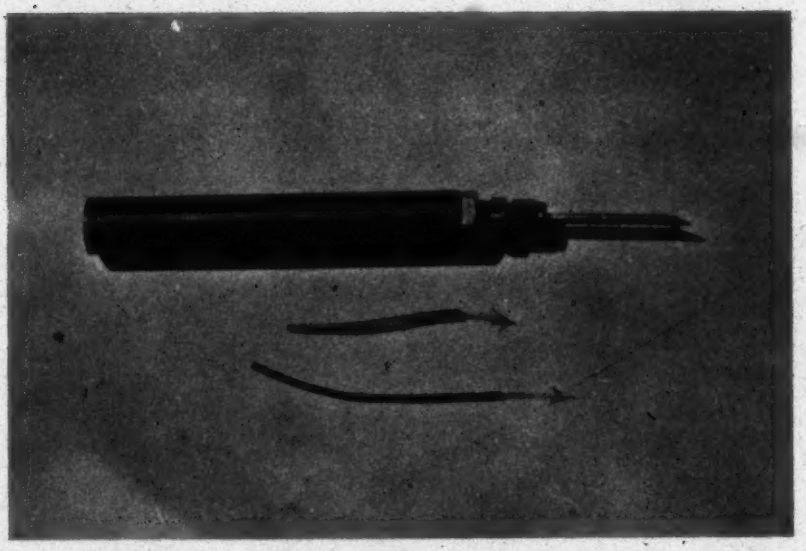


FIGURE 6. GILL NET SETS AND SEINING LOCATIONS



Photograph 3. Trough-like apparatus used for holding fish during the tagging operation.

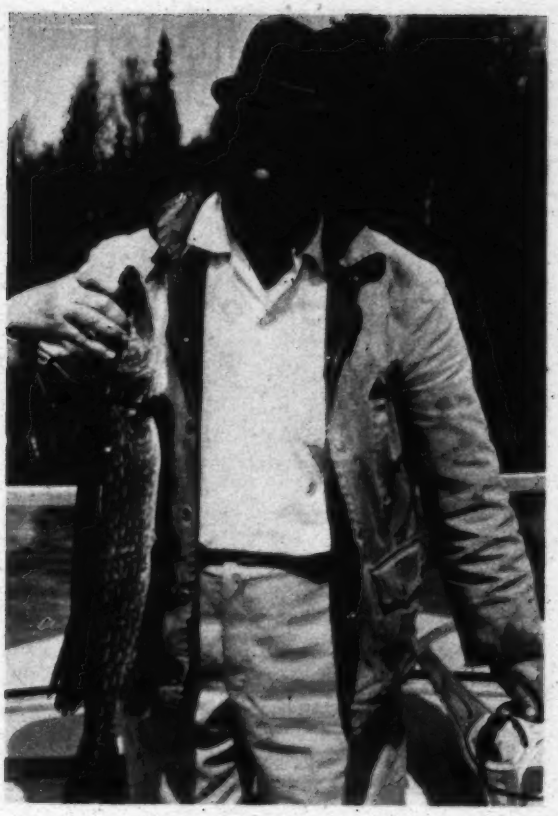


Photograph 4. Applicator and tags used in tagging operation.

tag number and location of capture (see Appendix III (A) and (B) for a complete list of tagged fish).

In most cases fish were out of the water for less than 25 seconds and when released fish did not appear to be adversely affected. Tags in most cases did not stick out but clung to the side of the fish (Photograph 5).

Green tags and yellow M00-series were used in 1971; yellow S00-series were used in 1972.



Photograph 5. Position of tag on a northern pike. Note how the tag clings to or parallels the contour of the northern pike.

RESULTS

A. GENERAL LIMNOLOGY

Physical and Chemical Characteristics

Seibert Lake is shallow lake with a mean depth of 19.9 feet (6.1 m) and a maximum depth of 36 feet (11 m). Morphometric data for Seibert Lake is shown in Table 2 and a contour map is illustrated in Figure 7.

With the length of the lake situated in a northwest-southeast direction the lake is well exposed to the prevailing winds from the northwest. This results in a thorough mixing of the lake at all depths thus a lack of a distinct thermocline or an oxycline as indicated in Table 3. An area where some stratification did occur was in the minor basin which is located in the northwest corner (S_7 and S_8) thus it is less exposed to the prevailing winds.

Water transparency (light penetration) was determined with a secchi disc at all the sampling locations indicated previously in Figure 4. The mean secchi disc reading during the month of July was 9.63 feet (2.93 m). One reading was taken in May indicating a water transparency of 17 feet (5.2 m).

Appendix IV indicates a chemical analysis of a sample of water from Seibert Lake. The Division of Pollution Control Laboratory within the Alberta Department of the Environment provided the analytical report.

The analysis showed that the water is alkaline and it indicated a value of 336 mg/l for the total dissolved solids (total residue).

TABLE 2. Morphometric parameters of Seibert Lake

PARAMETER		
Surface area	13.9 sq miles (8,896 acres)	(36.0 sq km)
Volume	177,030.4 acre feet	(21.8 x 10^7 m^3)
Maximum depth (Z_m)	36 feet	(11.0 m)
Mean depth ($\bar{Z}$)	19.9 feet	(6.1 m)
Maximum length	6.87 miles	(11.1 km)
Maximum width	3.31 miles	(5.3 km)
Shoreline length	21.80 miles	(35.1 km)
$\bar{Z}/Z_m$	0:55	
Percentage of lake area less than 10 ft (3.05 m) deep		21.9
Percentage of lake area 10 to 20 ft (3.05 - 6.10 m) deep		26.3
Percentage of lake area 20 to 30 ft (6.10 - 9.15 m) deep		28.1
Percentage of lake area over 30 ft (9.15 m) deep		23.8

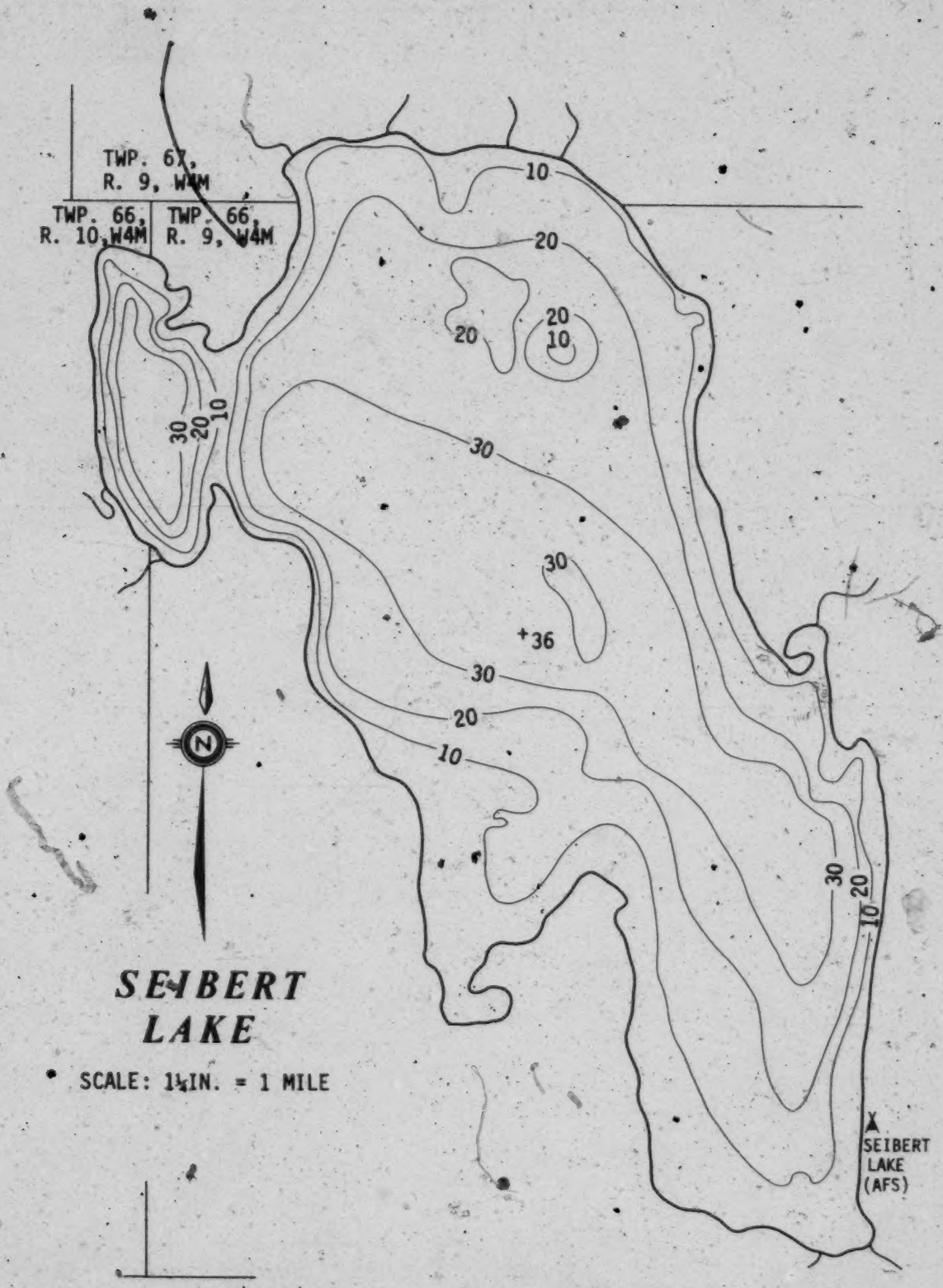


FIGURE 7. CONTOUR MAP OF SEIBERT LAKE

TABLE 3. Oxygen and temperature readings at Seibert Lake (July 12 to August 10, 1971)

Depth of Sample	Sample Size	Mean Oxygen (ppm)	Mean Temperature (° C)
Surface	16	5.6	16.2
5 ft (1.5 m)	16	5.5	16.2
10 ft (3.0 m)	16	5.4	16.15
15 ft (4.5 m)	16	5.3	16.15
20 ft (6.0 m)	16	5.3	16.15
25 ft (7.5 m)	15	5.2	16.15
*30 ft (9.0 m)	7	4.9	16.1

* One sample taken in S7, northwest corner of the lake, had an oxygen reading of 2.9 ppm.

Northcote and Larkin (1956) demonstrated the importance of total dissolved solids concentration as an indicator of lake productivity. Ryder (1965) indicated a method for estimating the potential fish production utilizing total dissolved solids and average lake depth. Thus the morphoedaphic index equals

$$\frac{\text{Total Dissolved Solids (ppm)}}{\text{Mean Lake Depth (feet)}} = \frac{336}{19.9} = 16.9$$

Plankton

Table 4 represents the counts of zooplankton from the various sampling locations. Copepods (mainly *Cyclops* sp. but also *Limnocalanus* sp.) form the bulk of the zooplankton, 89.1 per cent; cladocerans(*Daphnia* sp. and *Diaphanosoma* sp.) are constantly present (10.6 per cent) while the ostracods and amphipods are rare as zooplankton.

Two areas formed the extremes in abundance of zooplankton (S 12, 240 and S 8, 1250); all other areas were quite uniform in abundance.

The phytoplankton was not very abundant and no obvious mid-summer blooms occurred.

Bottom Types and Bottom Fauna

The general limnological bottom samples were taken in the fourteen lake zones previously indicated in Figure 4.

The bottom types seem to add to the statement that Seibert is a mesotrophic lake, in that, very little of the bottom type is silty or organic. Table 5 indicates the bottom types at various depths. At 30 (9.0 m), 25 (7.5 m) and 20 feet (6.0 m) depths a silty gray mud was the characteristic bottom type. The 15 (4.5 m), 10 (3.0 m) and 5 feet (1.5 m) levels were mainly sand and gravel substrates. The 5 feet (1.5 m) level did have some organic mud (36%). Vegetation was quite common in water less than 15 feet (4.5 m) deep.

TABLE 4. Zooplankton counts through 1932 cubic in. (34,486 cm^3) of water in the form of a ten foot vertical haul

Location	Zooplankton (mean numbers per 10 ft haul)				
	Copepoda	Cladocera	Ostracoda	Amphipoda	Total
S 1	604	99			703
S 2	457	55			512
S 3	388	73	4		465
S 4	545	68	2		615
S 5	601	71	2		672
S 6	483	54	2		539
S 7	683	55		2	740
S 8	1113	135	2		1250
S 9	502	36	2	1	541
S10	399	46	1		446
S11	430	27			457
S12	195	45			240
S13	428	41	5		474
S14	468	66	2		531
Mean	521.1	62.2	1.1		585.1
Percent	89.1	10.6	.2	.1	

TABLE 5. Bottom types at six measured depths

Depth	Number of Samples	Percent Silty Gray Mud	Percent Sand Gravel and Rock	Percent Black Organic Mud	Percent Vegetation
30 ft (9.0 m)	4	100			
25 ft (7.5 m)	11	100			
20 ft (6.0 m)	13	77	23		
15 ft (4.5 m)	15	13	87		73
10 ft (3.0 m)	16		94	6	88
5 ft (1.5 m)	14		64	36	86
Overall	73	37	55	8	51

The abundance of bottom fauna in number and in weight is illustrated in Figure 8. The total mass of the 15 (4.5 m), 10 (3.0 m) and 5 feet (1.5 m) samples was quite uniform and much greater than the weights of the 30 (9.0 m), 25 (7.5 m) and 20 feet (6.0 m) samples. Figure 8 also shows the numbers of different species found at any particular depth and the 10 feet (3.0 m) depth indicates the greatest diversity of 7.2 species per sample.

Table 6 shows a complete list of the basic groups of bottom fauna at various depths. Table 7 indicates the major organisms found in the six measured depths. The four most common organisms are dipterans *(Tendipes)*, amphipods *(Hyalella, Gammarus)*, ephemeropterans *(Ephemera)* and molluscans *(Pisidium, Gyraulus)*.

A complete list of the genera of bottom fauna is found in Appendix V.

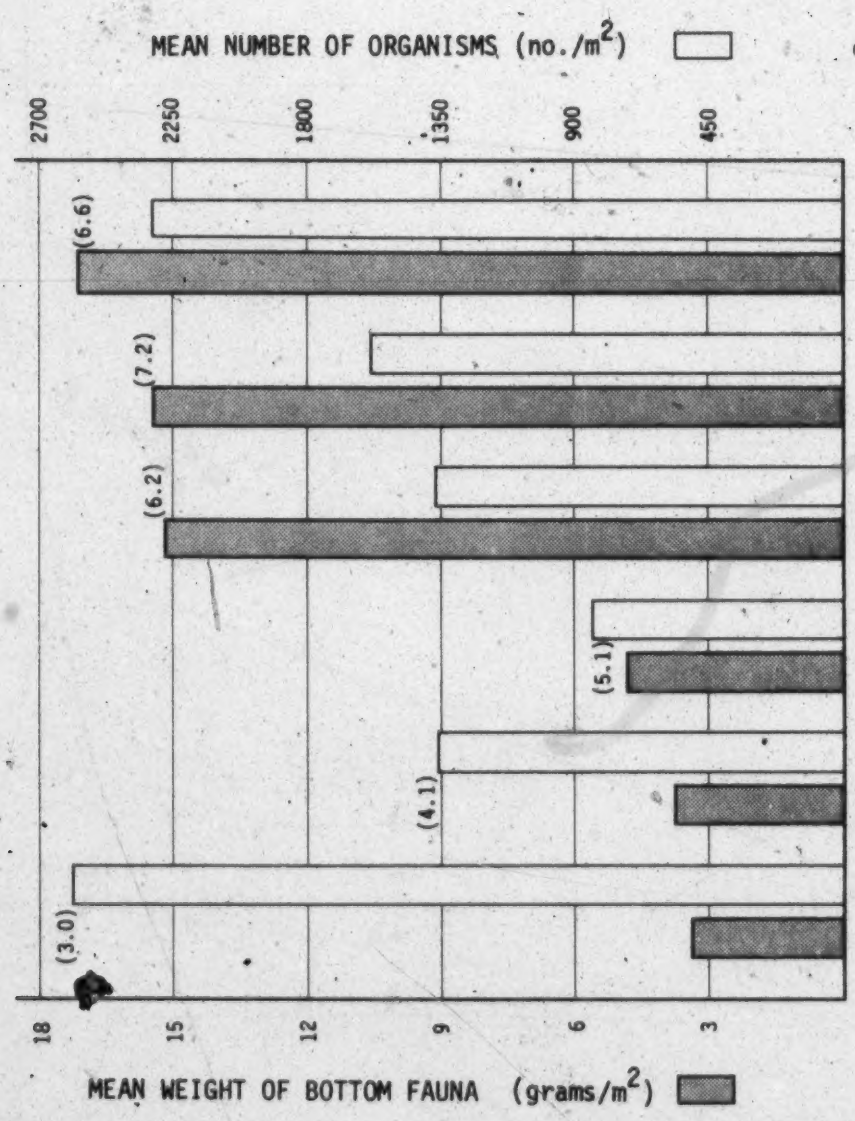


FIGURE 8 BOTTOM FAUNA FROM ALL MEASURED DEPTHS

TABLE 6. Abundance of bottom fauna at various depths.

Organism	Mean Numbers at Measured Depths					
	$\bar{x}$ 30'	$\bar{x}$ 25'	$\bar{x}$ 20'	$\bar{x}$ 15'	$\bar{x}$ 10'	$\bar{x}$ 5'
Amphipoda	92.5	232.2	275.2	933.1	1098.7	840.7
Diptera	2479.0	1064.3	440.8	96.8	77.4	898.7
Ephemeroptera			30.1	178.5	225.8	339.7
Trichoptera	6.5		4.3	23.7	43.0	28.0
Hemiptera		2.2				
Coleoptera						10.8
Odonata					2.2	
Hirudinea	6.5	10.8	10.8	17.2	19.4	28.0
Oligochaeta			2.2	34.4	23.7	23.7
Mollusca	21.5	47.3	83.9	64.5	81.7	159.1
Osteichthyes				1.0		
Platyhelminthes					6.5	
Total $\bar{x}$ no.	2601.5	1358.8	847.1	1373.9	1582.4	2328.5
n	4	11	13	15	10	10
$\bar{x}$ weights (gm) per m^2	3.44	3.87	4.73	15.28	15.49	17.22
$\bar{x}$ volume displacement ml per m^2	4.73	3.44	4.52	14.0	13.77	15.92

TABLE 7. Major bottom fauna

Depth	Major Organisms (percent)					
	1st		2nd		3rd	
30 ft (9.0m)	Diptera	95.2	Amphipoda	3.5	Mollusca	1.0
25 ft (7.5m)	Diptera	78.4	Amphipoda	17.1	Mollusca	3.5
20 ft (6.0m)	Diptera	52.1	Amphipoda	32.4	Mollusca	10.0
15 ft (4.5m)	Amphipoda	68.0	Ephemeroptera	13.0	Diptera	8.7
10 ft (3.0m)	Amphipoda	69.4	Ephemeroptera	14.3	Mollusca (Diptera	5.1 5.0)
5 ft (1.5m)	Diptera	38.6	Amphipoda	36.1	Ephemeroptera	14.6

B. FISHES

Seibert Lake has a history of large northern pike, numerous walleye and lake whitefish. Some of the other fishes inhabititing Seibert were determined with some difficulties and some questions remain unanswered.

The list of species found in Seibert include:

1. Northern Pike *(Esox lucius* Linnaeus*)*
2. Walleye *(Stizostedion vitreum vitreum)* (Mitchill)
3. Yellow Perch *(Perca flavescens* Linnaeus*)*
4. Lake Whitefish *(Coregonus clupeaformis)* (Mitchill)
5. Iowa Darter *(Etheostoma exile)* (Girard)
6. Burbot *(Lota lota* Linnaeus*)*
7. Brook Stickleback *(Culaea inconstans)* (Kirkland)
8. White Sucker *(Catostomus commersoni)* (Lacepede)
9. Spottail Shiner *(Notropis hudsonius)* (Clinton)
10. Fathead Minnow *(Pimephales promelas* Rafinesque*)*

The fathead minnow *(Pimephales promelas)*, which was observed in only one walleye stomach, appears to be rare. Paetz and Nelson (1970) comment that fathead minnows and brook sticklebacks are frequently found together. Brook sticklebacks are quite common in certain areas of the lake thus possibly a small population of fathead minnows is present.

The brook sticklebacks were most abundant in one particular area S 13 (Photograph 6) where a beaver house is found in a channel leading into the S 13 bay.

A contradiction which was noticed in the commercial fishing records (Table 8, Alberta Fish and Wildlife records) is the presence of

Photograph 6. Channel leading into S13 Bay--brook sticklebacks are quite abundant in this area.

TABLE 8. Commercial Fish Records from Seibert Lake (Twp. 66, Rge. 9, W4th M)

Year	No. of Licences	Fish Weight in Pounds				
		Tullibee	Pike	Walleye	Whitefish	Total
1946-47	18		3,380	1,825	2,050	7,256
1947-48	9	1,105	1,580		1,697	4,382
1948-49	6	750	1,000			1,750
1949-50	4	4,962	6,101		7,265	18,328
1955-56	12		2,500	200	6,000	8,700
1956-57	5		1,950		17,640	19,590

cisco (tullibee) *(Coregonus artedii* Lesueur*)*. These records indicate that cisco were taken from 1947 to 1950 (three years) but no records of cisco taken in the 1955-56 or the 1956-57 years. No cisco were recorded in this study to indicate its prescence.

Many long-time anglers claimed that perch were non-existent in the lake. Very few perch seem to be present but some have been found in stomachs, in gill nets and in the seine samples. During the duration of the study no perch were caught by anglers, thus it is relatively unimportant as a sport fish in Seibert Lake.

The relative abundance of spottail shiners, Iowa darters and burbot seems to be largely unknown but from observations of various sampling techniques and stomach samples their numbers are not large.

The white suckers appear to be quite numerous.

The fishes that will be dealt with in some detail are the lake whitefish, walleye and northern pike.

LAKE WHITEFISH *(Coregonus clupeaformis)*

Often seen in very large numbers feeding on the surface, the whitefish population appears quite large in Seibert Lake. It is one of the three dominant fishes in the lake. In the spring the whitefish are in fairly shallow water, less than 10 feet (3.0 m), and appear to be quite numerous. In the summer they are occasionally found in large groups in the shallows, within a few feet of the shore and appear to be feeding on hatching ephemeropterans that have been blown into the shore. Many "schools" of 15-25 fish have been observed feeding near the surface in areas where water depth was 20-30 feet (6.0-9.0 m).

With large sand and gravel shorelines the whitefish have numerous spawning beds which also means that the whitefish are again found in fairly shallow water in the fall. The rocky gravel areas of S 1 and S 14 are ideal spawning areas and numerous whitefish have been observed in less than 5 feet (3.0 m) of water in October.

Growth

The "jumbo" whitefish is not characteristic of Seibert Lake. Figure 9 shows the relationship between age classes and length of males and females. Figure 10 shows the relationship between age classes and weight. The largest whitefish sampled was a 12+ male, 18.9 inches (481 mm) fork length and weighing 53 ounces (1504.1 g). But generally few whitefish of the higher age classes are heavier than two pounds (908 g). Length versus weight in graphed in Figure 11.

Appendix VI indicates the variation (standard deviation) in mean fork lengths and mean weights of age classes of whitefish.

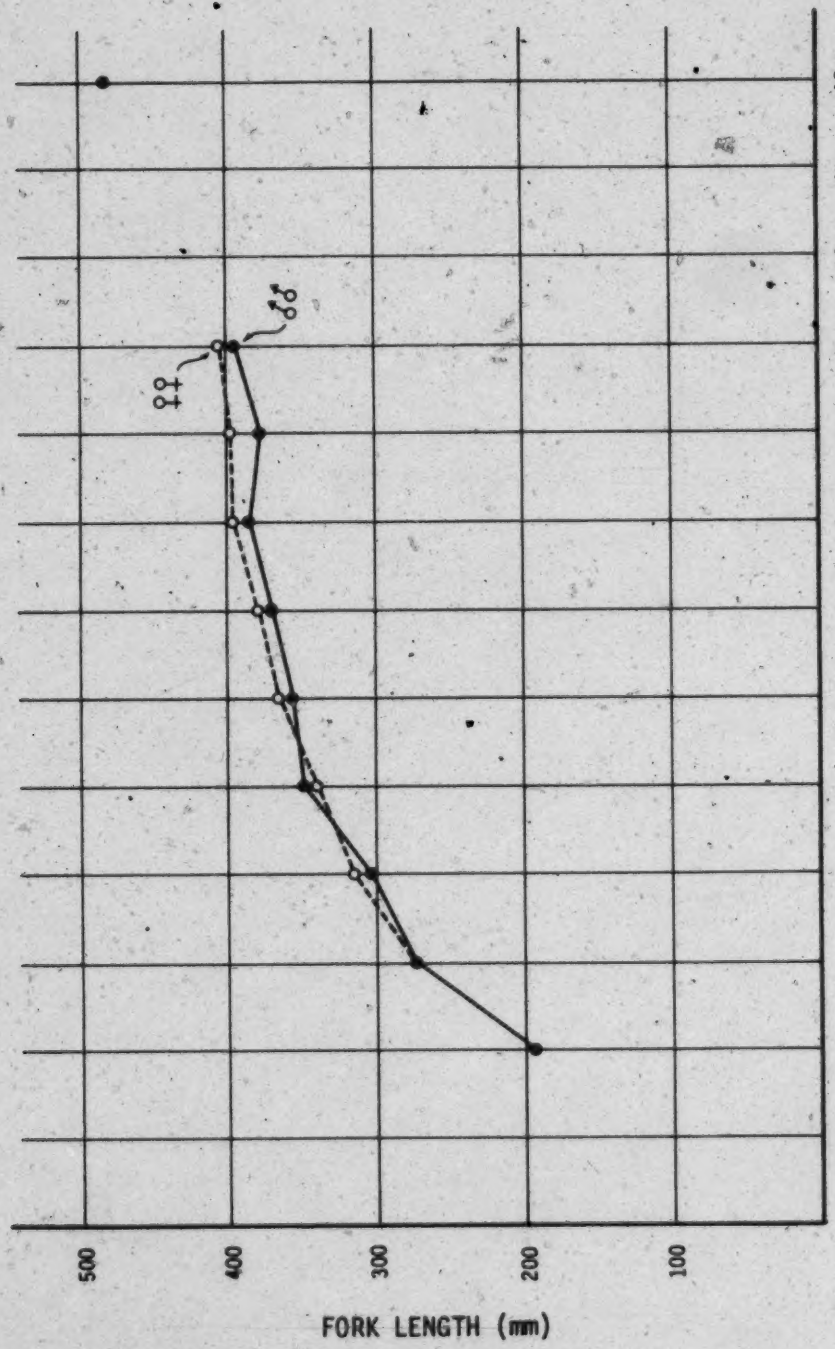


FIGURE 9 LAKE WHITEFISH: AGE - LENGTH RELATIONSHIP

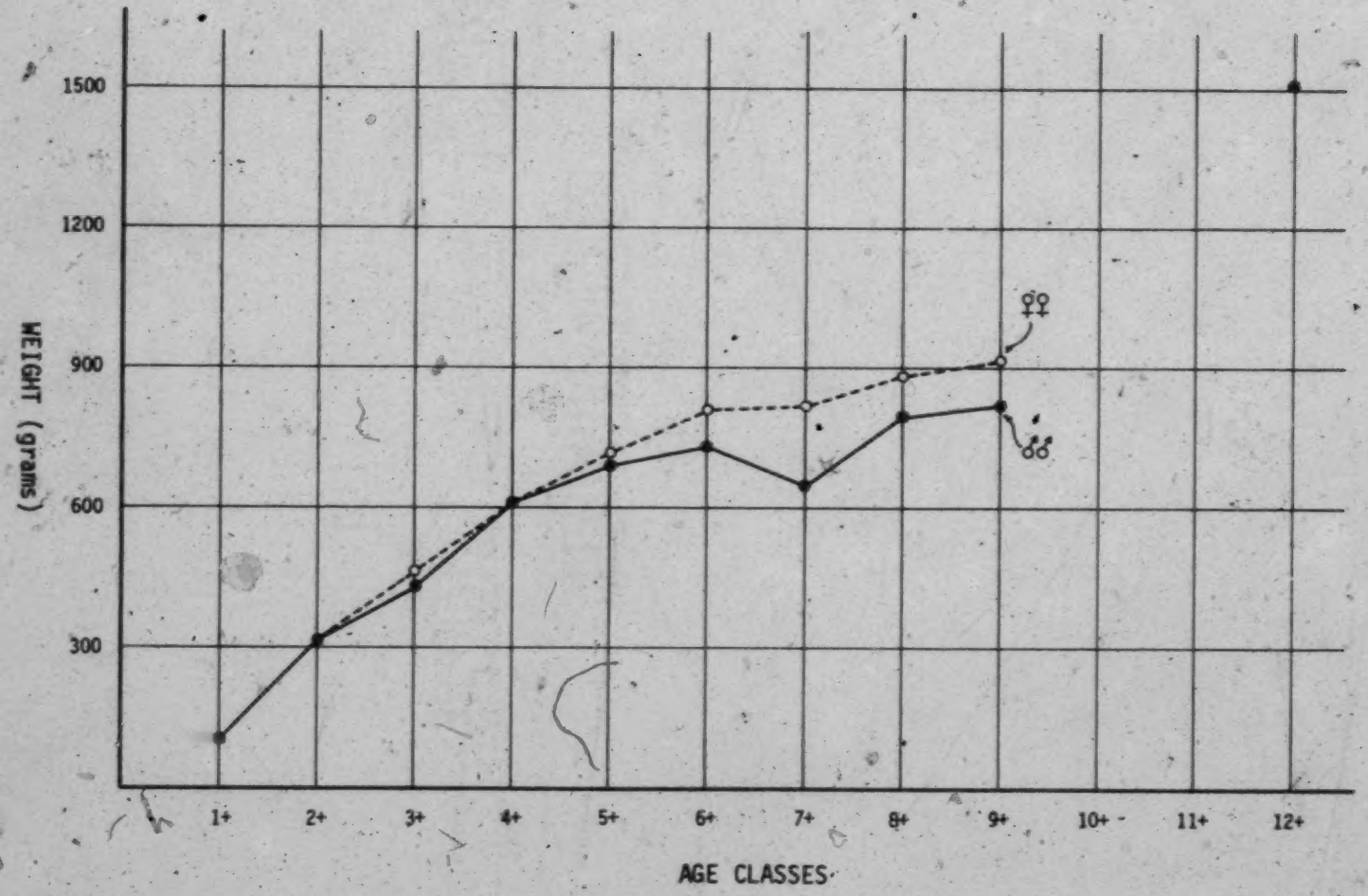


FIGURE 10 LAKE WHITEFISH: AGE - WEIGHT RELATIONSHIP

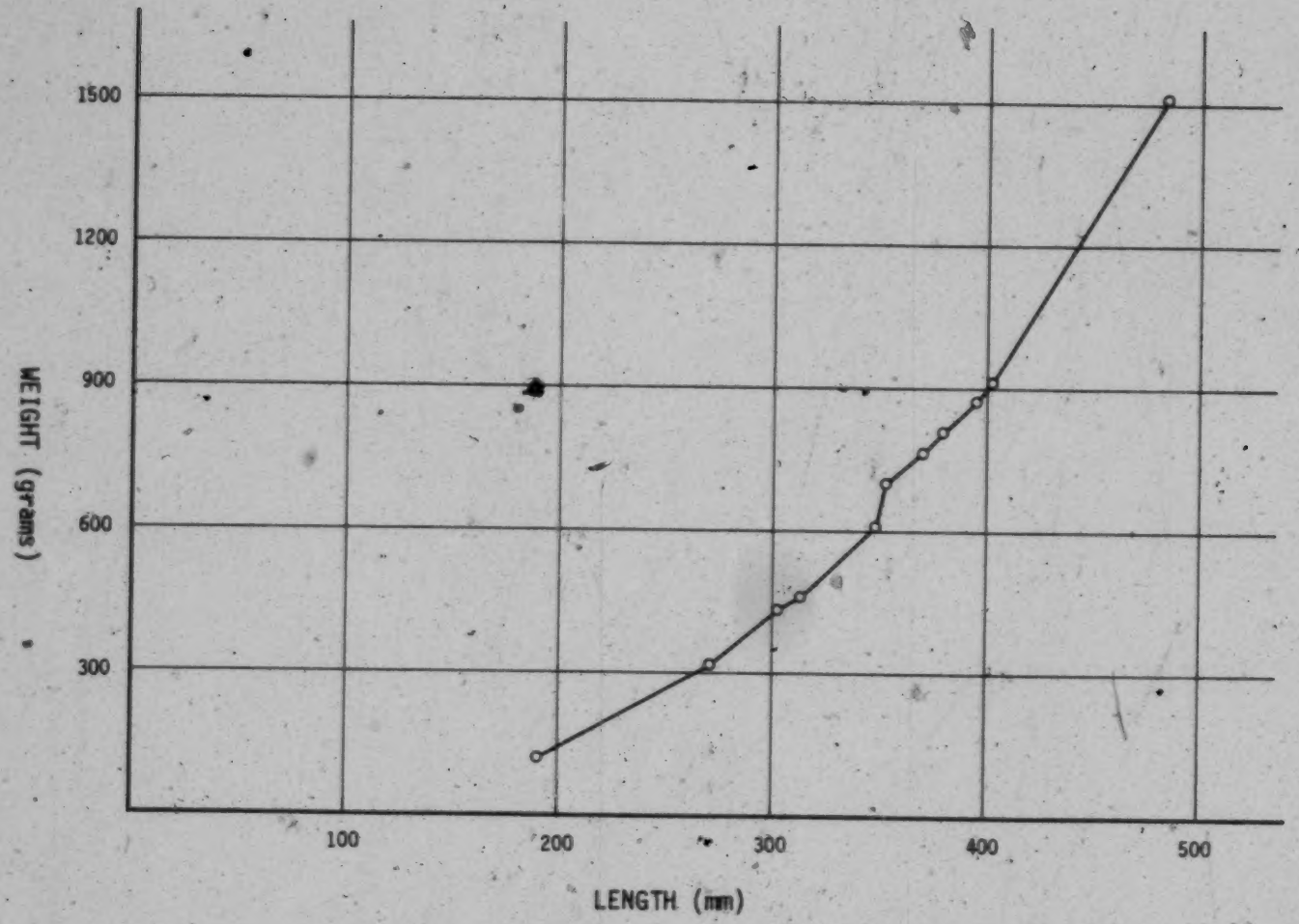


FIGURE 11 LAKE WHITEFISH: LENGTH - WEIGHT RELATIONSHIP

The greatest standard deviation in length occurred in age class 5+ where a deviation of 41.0 mm (1.61 in) occurred. The variation in weights was greatest in the age classes older than 6+. The 8+ age class showed a standard deviation of 184.6 grams (6.5 ounces).

Abundance of Age Groups

Figure 12 indicates the frequency of whitefish from different age classes. Age class 6+ was represented in the greatest numbers. Very few fish over the age of 9+ were sampled; the only older fish was a 12+ male which also represented the only whitefish over two pounds (908 grams) in weight.

Food of Lake Whitefish

The stomachs of 98 lake whitefish were checked and from 44, which contained food, identification and counts were made. Figure 13 illustrates the percentage occurrence food items found in the whitefish. The major items include: (percent occurrence)

1. Amphipoda (mainly *Hyalella*) 61.4%
2. Mollusca (mainly *Pisidium*) 36.4%
3. Diptera (mainly *Tendipes*) 34.1%
4. Ephemeroptera (mainly *Ephemera*) 25.0%

Other food items included members of the Hirudinea (leeches) Trichoptera (caddis flies), Hemiptera (backswimmers), Oligochaeta (segmented worms), Osteichthyes (fishes), Odonata (damselflies and dragonflies) and Coleoptera (beetles). The average number of items per whitefish stomach was 51.4.

Amphipods are the most common food item in the diet of lake

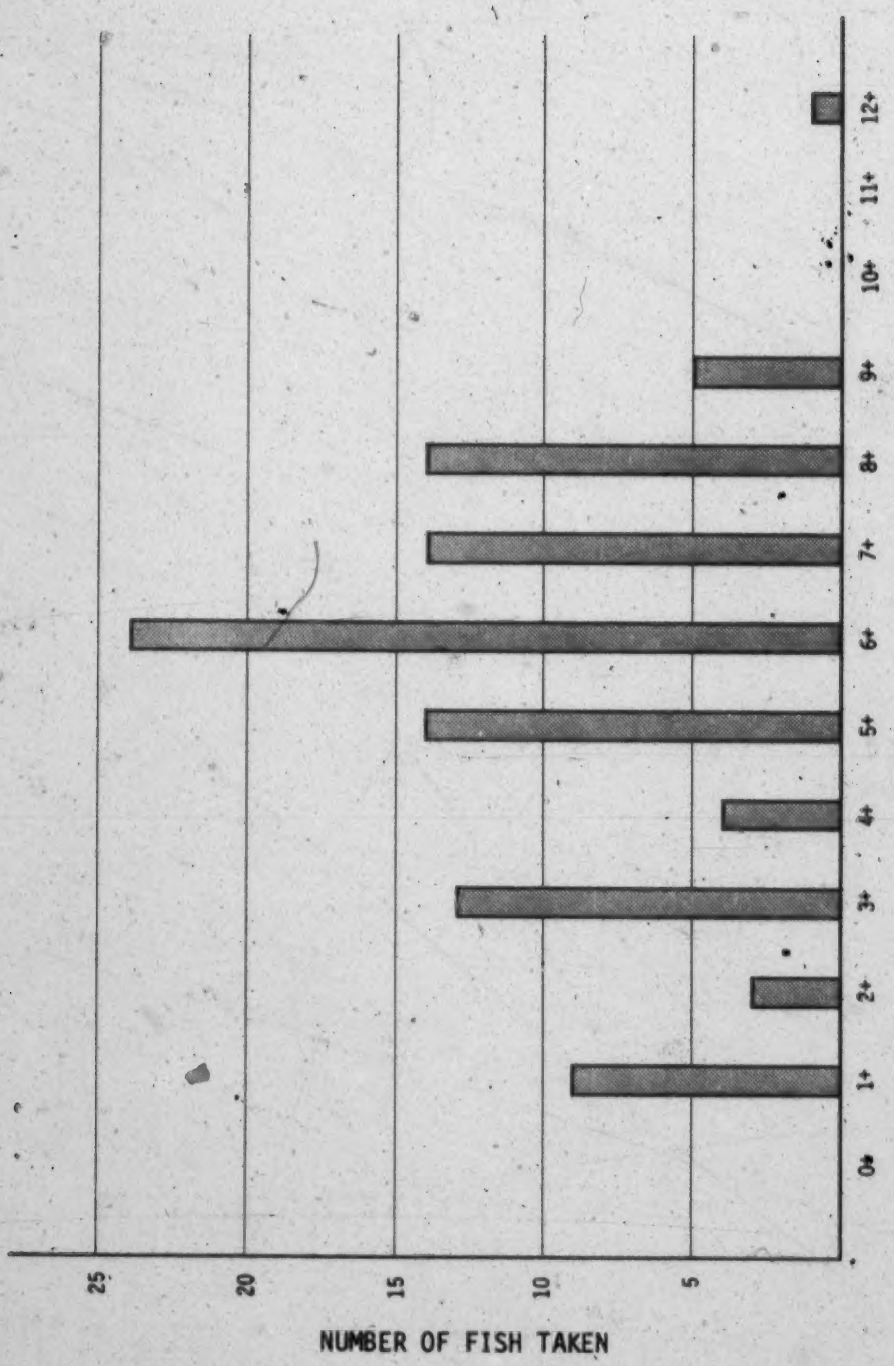


FIGURE 12 NUMBERS OF WHITEFISH OF DIFFERENT AGE CLASSES
(as sampled from test gill nets)

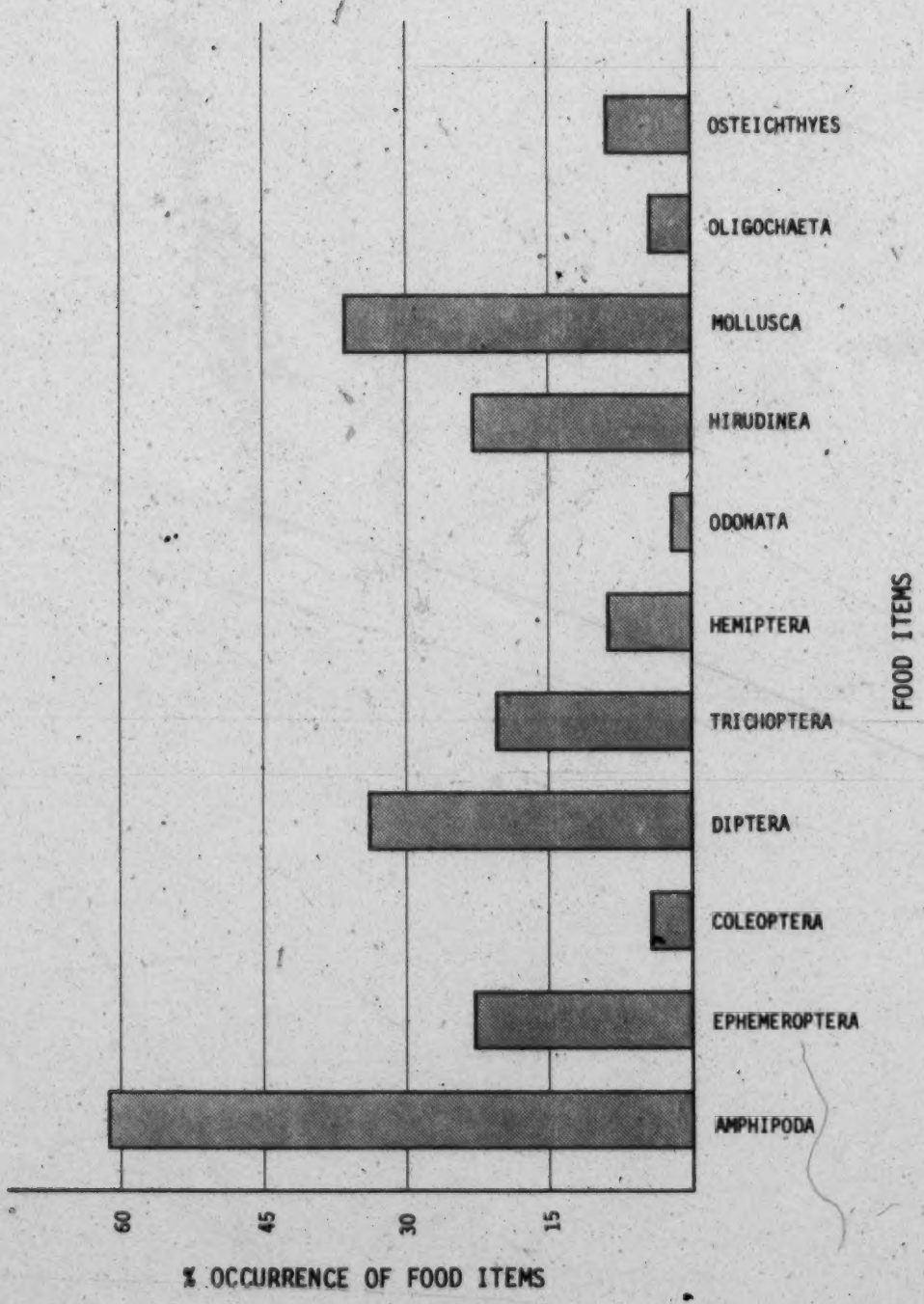


FIGURE 13 LAKE WHITEFISH - STOMACH CONTENTS

whitefish but quite often they feed exclusively on mayflies *(Ephemera)* as indicated by the average number of mayflies in those whitefish containing mayflies (67.7 - Appendix VII). In the early spring the whitefish feed on the nymph stage but when hatches occur (observed a hatch period of approximately 16 days in late June to early July) they literally pack their stomachs with adults or developing adults.

Appendix VII lists the food items, the total number of items, the average number of food items of each type and the percentage occurrence of food items.

Incidence of Cysts *(Triaenophorus crassus)* in Lake Whitefish

Local residents and long-time regular visitors know Seibert as "Worm Lake". These people claimed that the pike and the whitefish in particular were "wormy". These observations were made during the years when commercial fishing was allowed on the lake and the parasite which was and is present is *Triaenophorus crassus* a tapeworm whose life cycle is described by Miller (1952).

Eighty-one whitefish were examined (Photograph 7) in order to determine the infestation percentage and thus commercial quality of the fish. Table 9 lists the data indicating the findings from the examination of whitefish. The mean number of cysts per 100 pounds of fish (round weight) is 349.2; the average number of cysts per fish is 5.17.

Angling and Commercial Fishing

Lake whitefish are of virtually no concern to the angler who visits Seibert even though a few are taken while anglers attempt to catch walleye. Thus in terms of harvest or exploitation sport fishing plays no direct role.

Photograph 7. Procedure used in the examination of cysts (*Triaenophorus crassus*) in lake whitefish. Note the elongated milky-like cyst in this photograph.

TABLE 9. Incidence of cysts (*Triaenophorus crassus*) in lake whitefish in Seibert Lake.

Number of lake whitefish examined (cut)	81
Total number of pounds	120.1 (1922 oz.)
Total number of cysts	419
Number of cysts per 100 pounds of whitefish	349.2
Range of cysts per fish	0-17
Mean weight of fish sampled	23.7 oz.
Mean number of cysts per fish	5.17

Commercial fishing records were previously indicated in Table 8. There has been no commercial fishing on Seibert since 1956. Commercial fishing thusly plays no role in terms of harvesting or exploiting the whitefish population.

WALLEYE *(Stizostedion vitreum)*

Although northern pike are of prime importance in the management of this trophy lake, the walleye are abundant and of such excellent quality that many anglers visit the lake with walleye as their major aim.

Large numbers of walleye were sampled from angler creels in both 1971 and 1972; the majority being sampled in May and early June. Various aspects which will be discussed include: growth, abundance of age classes, spawning, age of maturity, distribution and food of walleye.

Growth

Aging was done entirely with the aid of scales. Figure 14 represents the relationship between fork length and age classes and also distinguishes the growth between males and females. Females tended to be a little larger than males and they seemed to be more abundant in the higher age classes (9+ and 10+). The average length of angled walleye in the spring-summers of 1971-72 was 16.1 inches (410.2 mm).

Figure 15 represents the relationship between age classes and weight. The mean weight of 1074 angled walleye (spring-summer weights) was 25.7 ounces (727.5 grams).

Figure 16 shows the relationship between length and weight of walleye. The slope of this relationship is 4.8 (i.e grams per mm).

Females tend to be larger at age classes after 4 but greatest differences begin to occur at age 7. No males greater than age 8 were sampled.

Appendix VIII indicates the mean lengths, sample sizes and statistical variation in terms of standard deviation and standard error

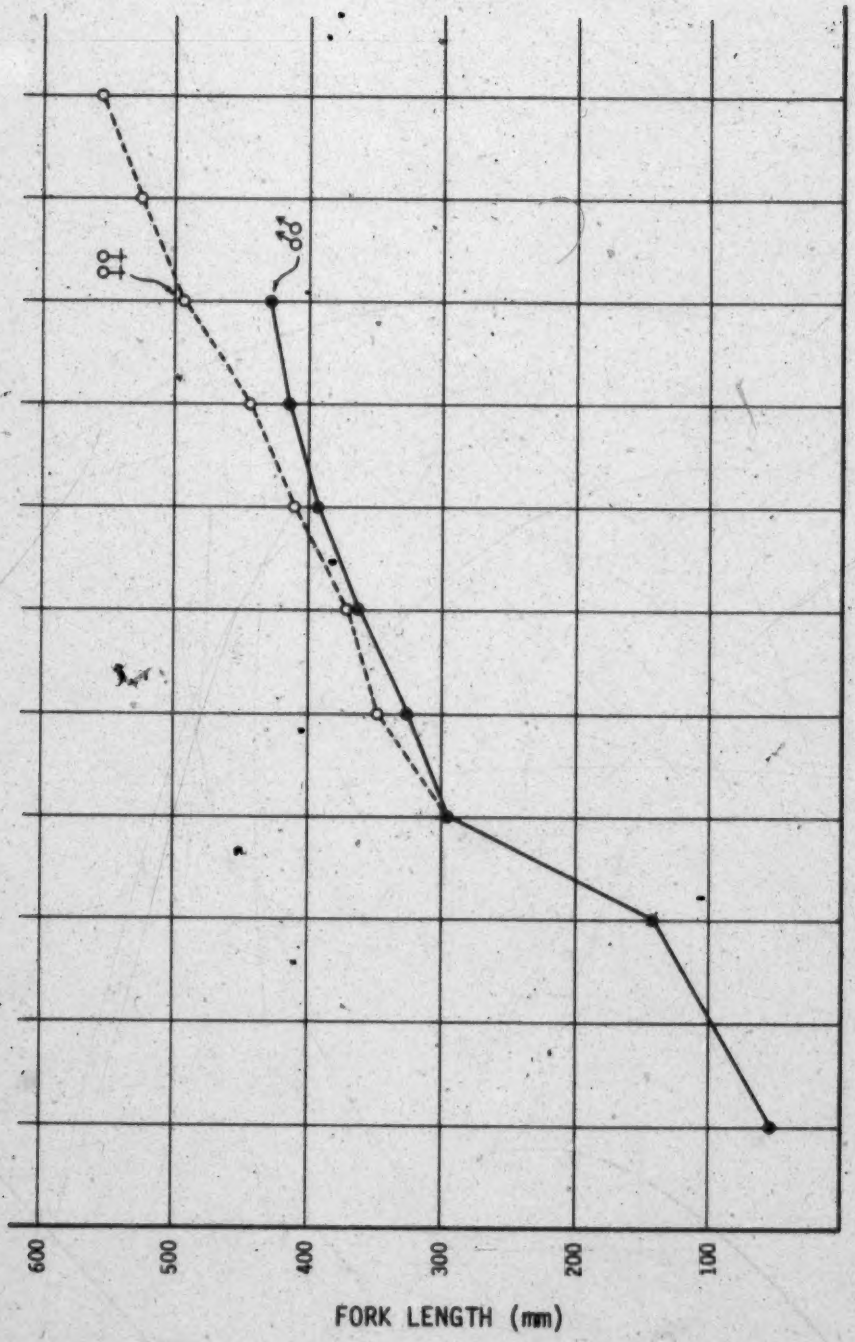


FIGURE 14 WALLEYE: AGE - LENGTH RELATIONSHIP

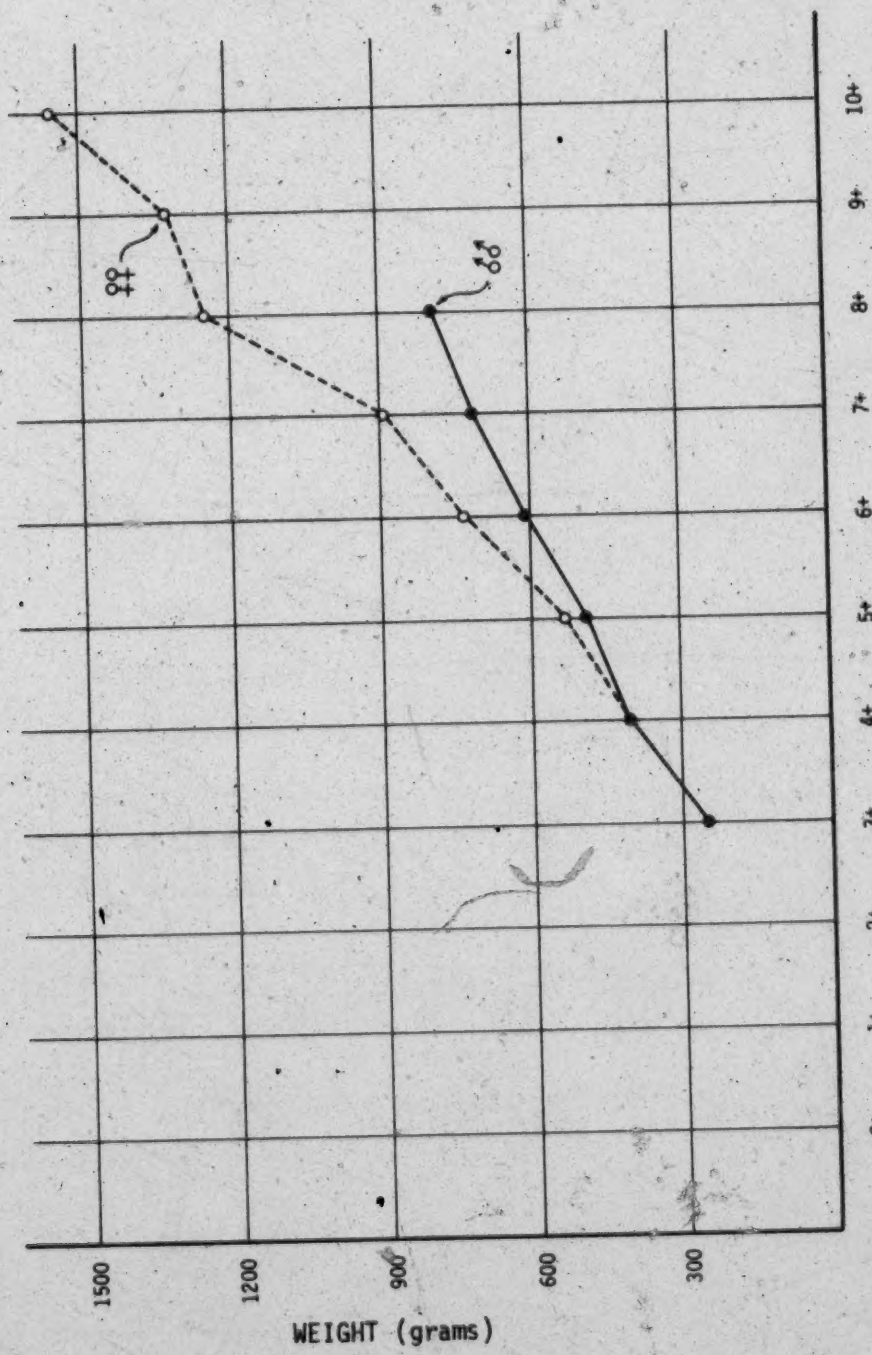


FIGURE 15 WALLEYE: AGE - WEIGHT RELATIONSHIP

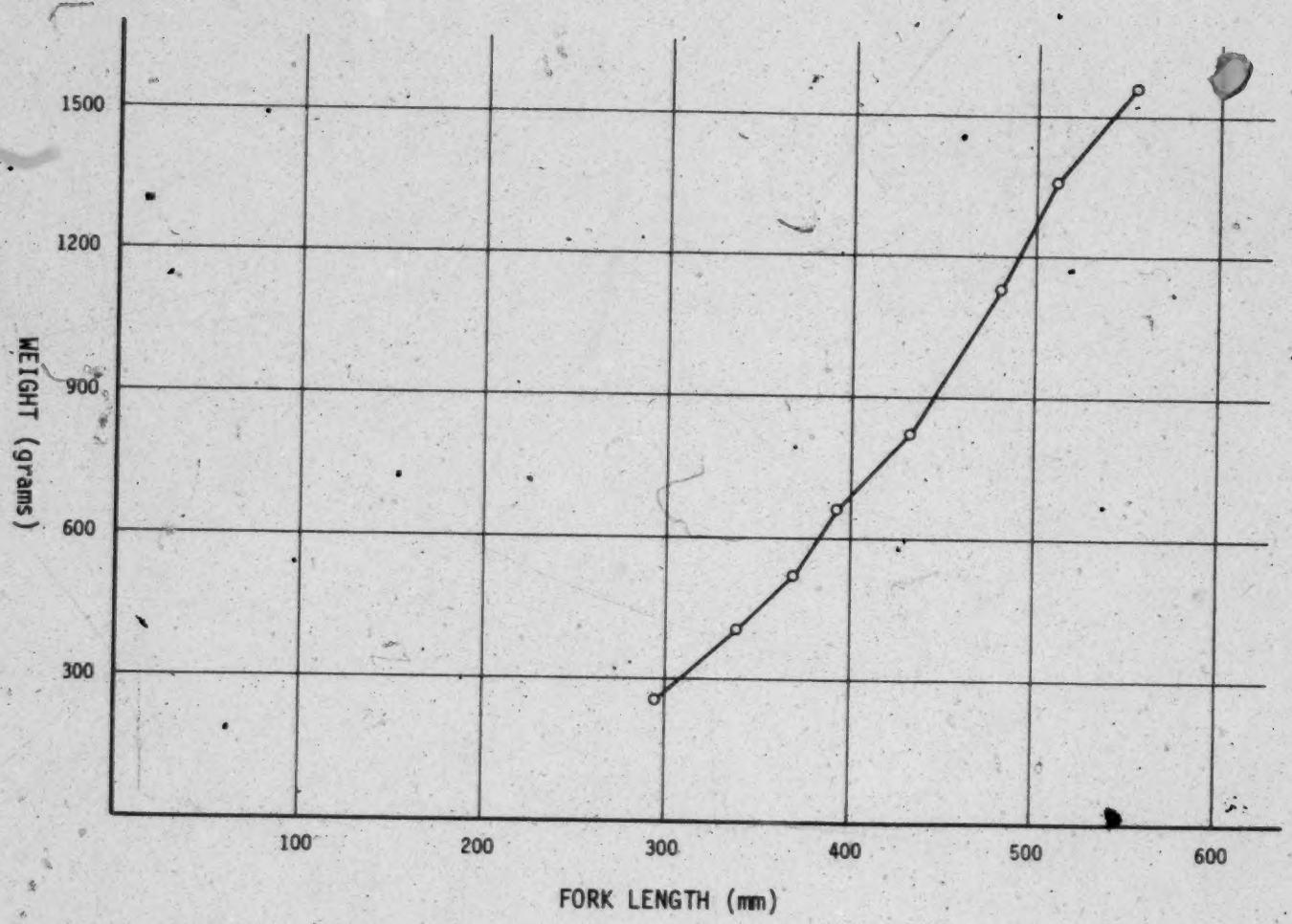


FIGURE 16 WALLEYE - LENGTH VS. WEIGHT

about the mean. The greatest variation is found in the older age groups: at age 9+, females had a standard deviation of 1.44 inches (36.2 mm).

Appendix IX states the variation in weights of all age classes from angled walleye. Again the greatest variation occurred in the older age groups and generally in females as opposed to males. The standard deviation of 9+ females was 11.6 ounces (330.6 grams); while the least variation from sampled walleye occurred in 4+ age class (standard deviation of 41.4 grams or 1.5 ounces).

The mean lengths of males and females were analyzed to determine whether statistically significant differences occur. The method used was a comparison of means from normal distributions and large sample size (30+). This formula is indicated by most statistical books (Bailey, 1959) and is indicated below:

$$Z = \frac{\bar{x}_1 - \bar{x}_2}{\frac{S_1}{\sqrt{n_1}} + \frac{S_2}{\sqrt{n_2}}}$$

Where $\bar{x}_1$ and $\bar{x}_2$ represent the mean lengths for males and females S_1 and S_2 represent the standard deviations for males and females. N_1 and N_2 represent the sample sizes for males and remales. Interpretation of Z values indicates whether differences are significant or not. The Z values comparing mean lengths of males and females for various age classes of walleye are stated and interpreted below.

Age Class	Z Value	Significance
5+	1.31	No significant difference

Age Class	Z Value	Significance (P = .001)
6+	7.59	♀♀ >> ♂♂
7+	7.92	♀♀ >> ♂♂
8+	5.72	♀♀ >> ♂♂

In the Selbert Lake walleye there is a significant sexual dimorphism indicated in the age classes 6+, 7+ and 8+ where the females were larger than the males. No males over the age of 8+ were sampled, but females 9+ and 10+ appeared to show increased growth while the male growth curve appears to level off.

Abundance of Age Classes

Figure 17 shows the numbers of angled walleye of the various age classes. The figure also shows the number of males, females and immatures of a particular age class. Females became more abundant at age 7+ and virtually no males were sampled from the 9+ and 10+ age classes. The overall sex ratio of males to females was 1.0:1.3.

The three major age classes from 1074 samples were: 6+ (39.7%), 7+ (32.7%) and 5+ (17.7%). No walleye over the age of 10+ were sampled.

Spawning and Age of Maturity

The walleye of Selbert spawn in many areas of the lake due to the abundance of sand and gravel along much of the shoreline. Actual observations and sampling of fish from specific areas indicated definite spawning areas in S14, S 1, S 7 and S11. In S 1 and S14 observations of walleye in 3 to 12 feet (1 - 4 m) were noted. Females were generally found in either a ripe or a spent condition while males were often found in a partially spent condition. Males were found to linger in shallow water much longer than females. In one case, observed in early June,

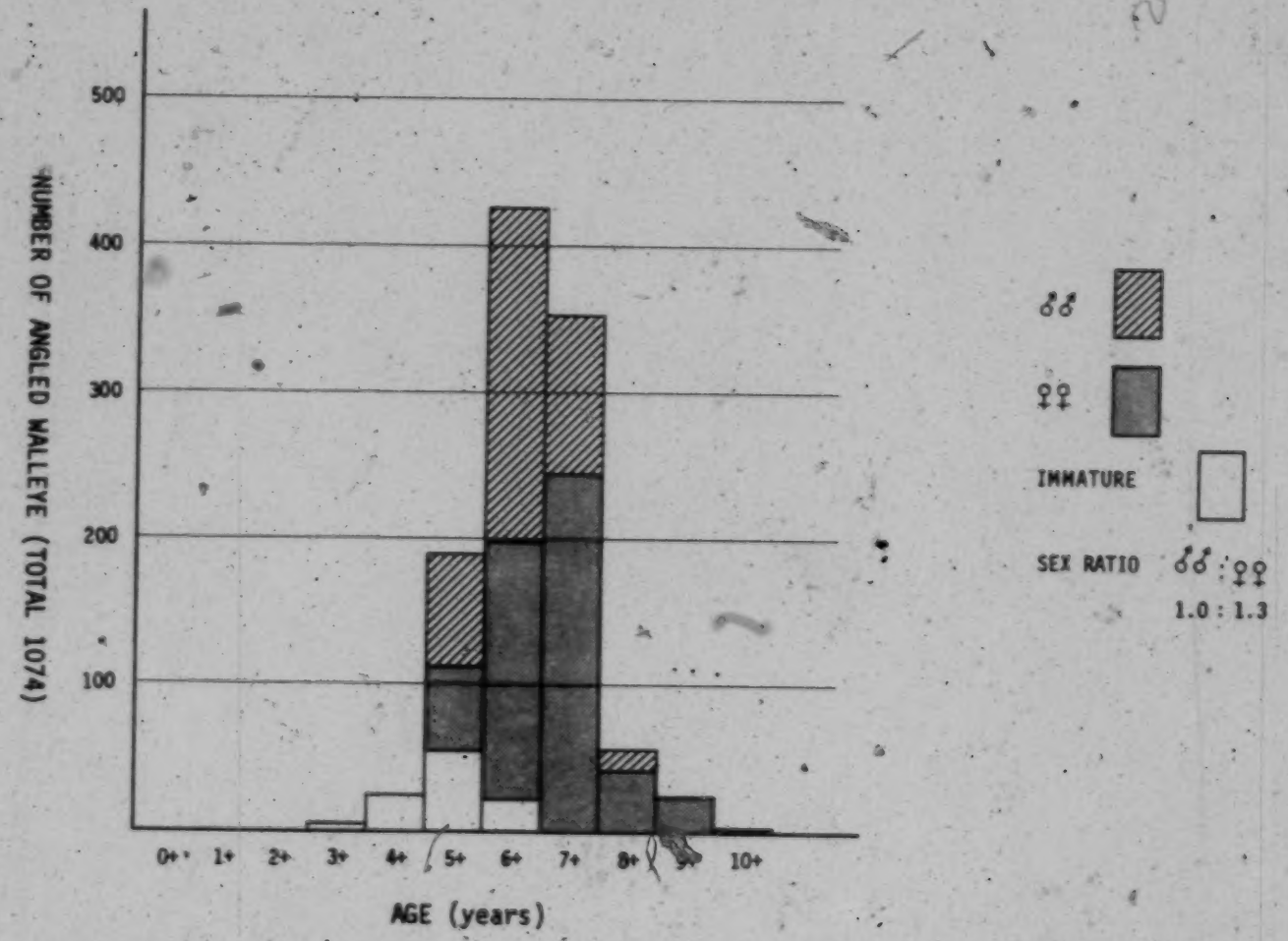


FIGURE 17 WALLEYE: FREQUENCY OF DIFFERENT AGE CLASSES

male walleye were found closely associated with white suckers believed to be spawning. Both the white suckers and the male walleye were in water less than two feet (61 cm.). The male walleye were in a partially spent condition.

The above mentioned areas are by no means the only areas where walleye spawn. There are many suitable areas in other lake zones but the above mentioned areas were recorded as having large numbers of walleye during the peak spawning periods.

Also of note is that the fall spawning lake whitefish use very much the same spawning areas as do the walleye.

Spawning times differed in the springs of 1971 and 1972. Figures 18 (a) and 18 (b) show the spawning peaks for 1971 and 1972 respectively. In 1971 the ice left the lake on May 9 while in 1972 it left the lake May 15. All fish were spent by May 29 in 1971; all were spent by June 3 in 1972.. The peak of spawning in 1971 appears to be about May 16-17 while in 1972 the first spent females were noted on May 18 and the peak was probably May 23-24..

The age of maturity is described in Table 10. The table indicates that nearly all males are mature at age 5+. The females are quite different in that very few (6%) are mature at 5, 56% are mature at 6 and 90% at age 7. The age 7 females that appear to be immature may be sterile, their size is greater than the mean for that age class. The occasional 8 and 9 year old females seemed to be "immature or sterile" and also were larger than the average size for their respective age classes.

Distribution of Walleye in Seibert Lake

Table 11 shows the abundance of angler caught walleye in

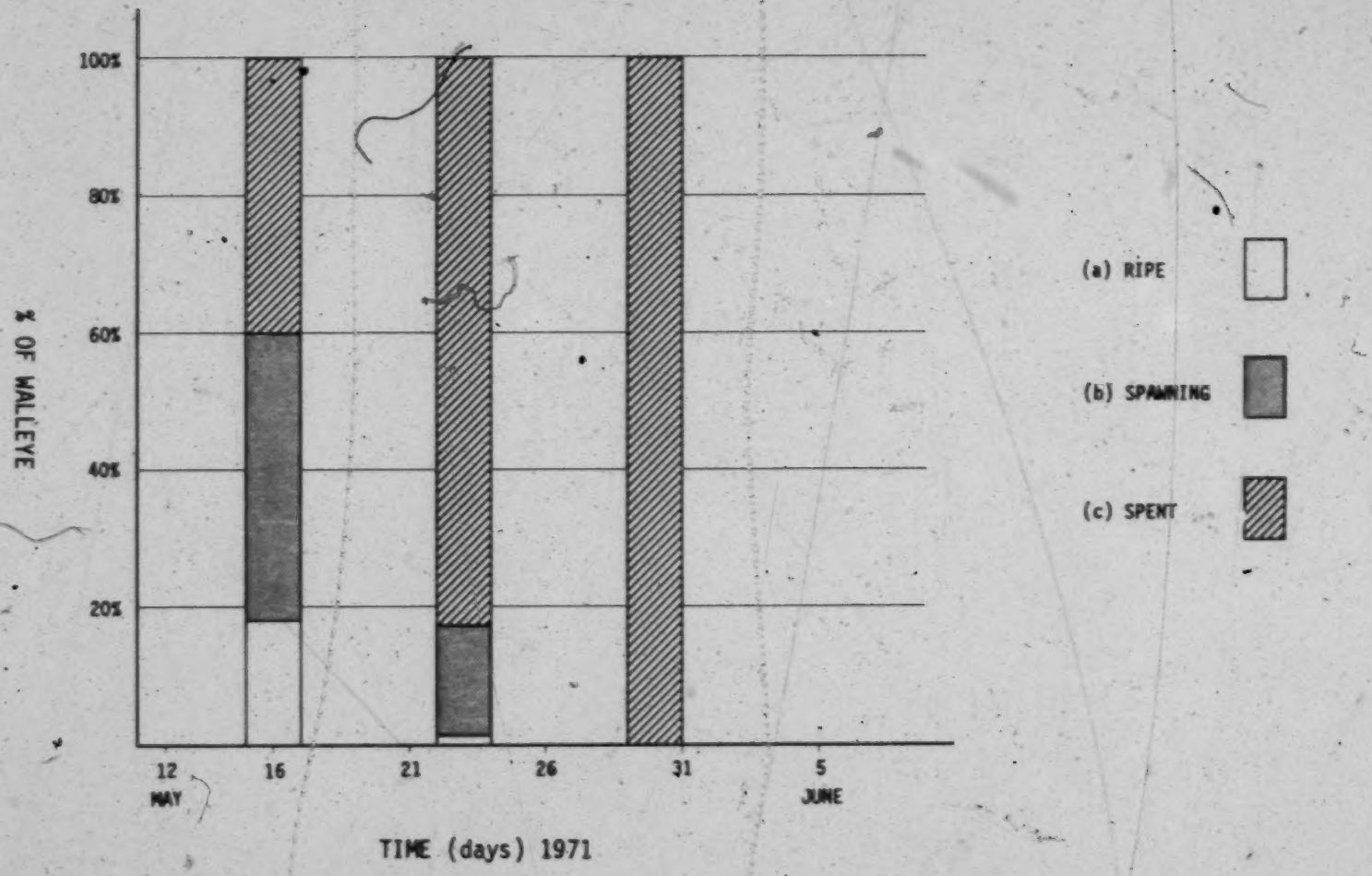


FIGURE 18(a) WALLEYE: PEAK SPAWNING 1971

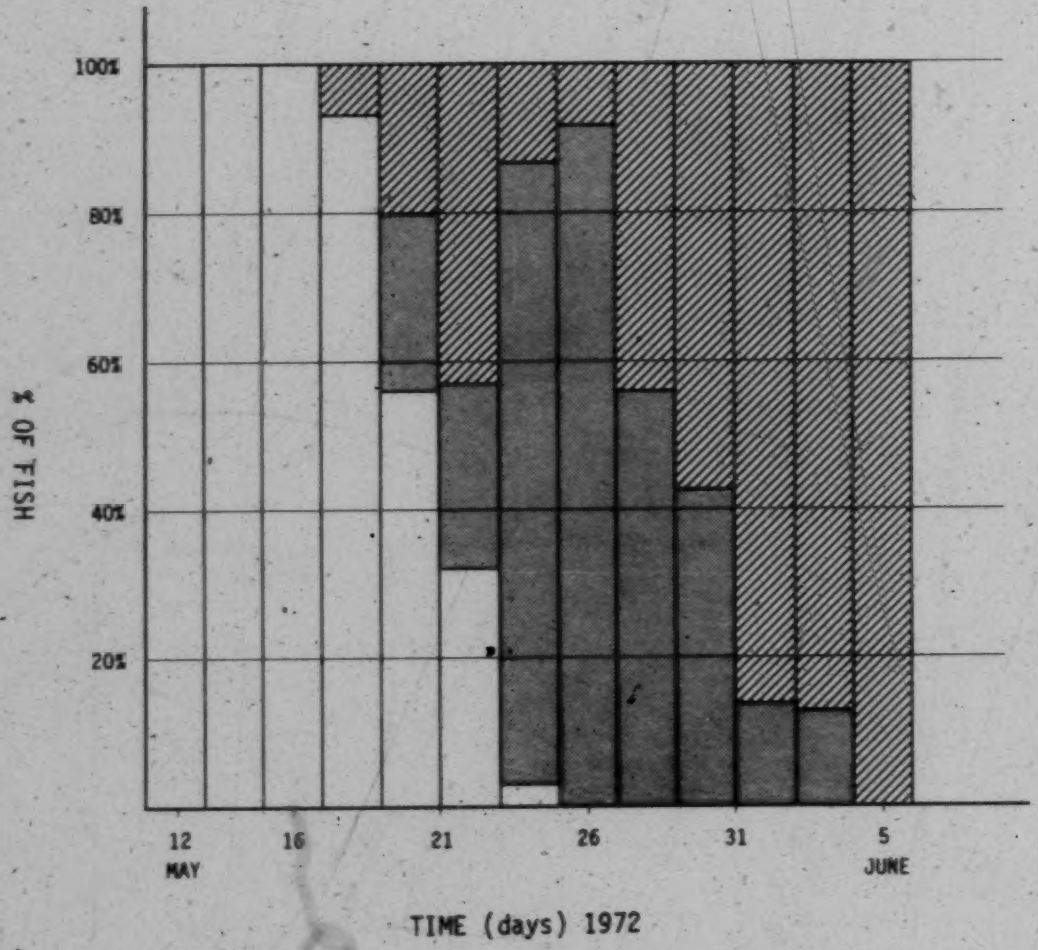


FIGURE 18(b) WALLEYE: PEAK SPAWNING 1972

TABLE 10. Walleye Maturity

Age Classes	Percent Mature Males	Percent Mature Females
4+	0	0
5+	98 (49/50)	6 (4/57)
6+	100	56 (57/102)
7+	100	90 (135/150)
8+	100	100

TABLE 11. Walleye caught 1971 and 1972

Lake Zone	Number of Walleye Released	Number of Walleye Retained	Total Number Caught	Percent Released	Percent Retained	Percent of Total Caught
S 1	120	370	490	11.0	14.5	13.5
S 2	41	122	163	3.8	4.8	4.5
S 3	19	48	67	1.7	1.9	1.8
S 4	0	6	6	0	0.2	0.1
S 5	46	268	314	4.2	10.5	8.6
S 6	0	3	3	0	0.1	0.05
S 7	81	130	211	7.5	5.1	5.8
S 8	102	223	325	9.4	8.7	8.9
S 9	88	240	328	8.1	9.4	9.0
S10	48	44	92	4.3	1.7	2.5
S11	69	71	140	6.3	2.8	3.8
S12	23	59	82	2.1	2.3	2.3
S13	66	254	320	6.1	10.0	8.8
S14	384	712	1096	35.3	27.9	30.1
Total	1087	2550	3637			

various parts of the lake. The numbers released as well as those retained are indicated. Figure 19 better portrays the lake zones of importance to overall walleye angling.

Two areas S 4 and S 6 were very poor producers of walleye in the spring-summers of 1971 and 1972. The zone of greatest walleye production was S 14 (30.1%) but generally all other areas seemed to produce some walleye ranging from 1.8 to 9.0 per cent of the overall catch. Northern pike distribution will be compared with walleye distribution in a later section.

Of the total (3637) walleye caught 70.1% were retained while 29.9% were released.

Generally walleye tend to be widely distributed and appear to be quite plentiful.

Food of Walleye

Walleye generally tend to feed on the bottom and are considered nocturnal in terms of feeding activities (Neimuth et al., 1959). In Seibert the walleye are feeding quite actively throughout the day with activity peaking in the evenings and nights. If walleye are feeding to a great degree on forage fish, they will be found moving into fairly shallow water in the evening as do the forage fishes. The activity of walleye during the entire day is indicative of their diets.

The stomach content data are tabulated in Appendix X. Figures 20 and 21 portray total number of organisms fed upon, mean number of organisms per stomach, per cent total food items and per cent occurrence.

The per cent occurrence of the major food types include:

1. Amphipods 58.9%

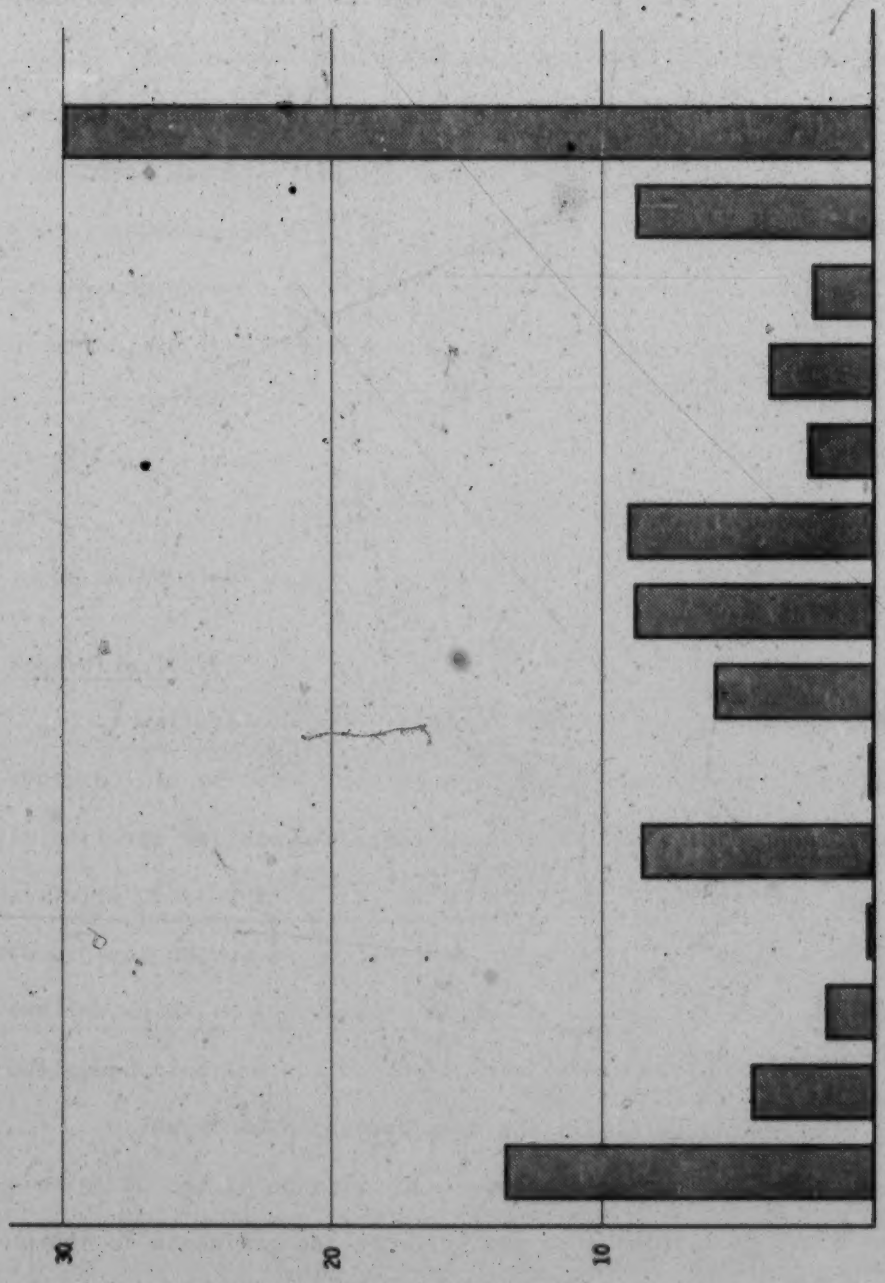

30
20
10
% OF WALLEYE CAUGHT - COMBINED RELEASED AND RETAINED DATA (TOTAL WALLEYE 3,637)
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14
LAKE ZONES (original random selections)

FIGURE 19 WALLEYE: LOCATIONAL ABUNDANCE

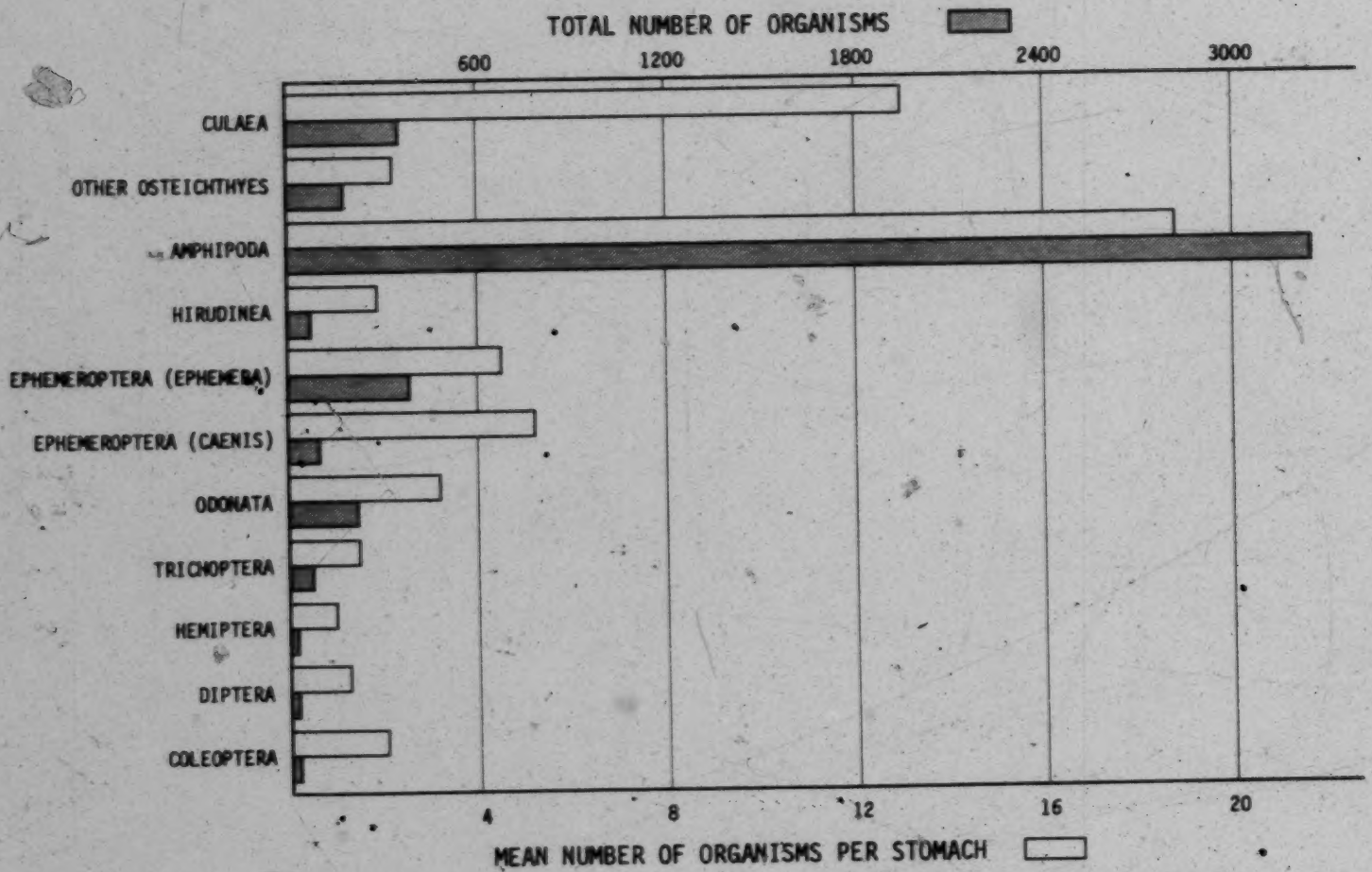


FIGURE 20 WALLEYE - STOMACH CONTENTS: NUMBER OF ORGANISMS FOUND IN WALLEYE STOMACHS

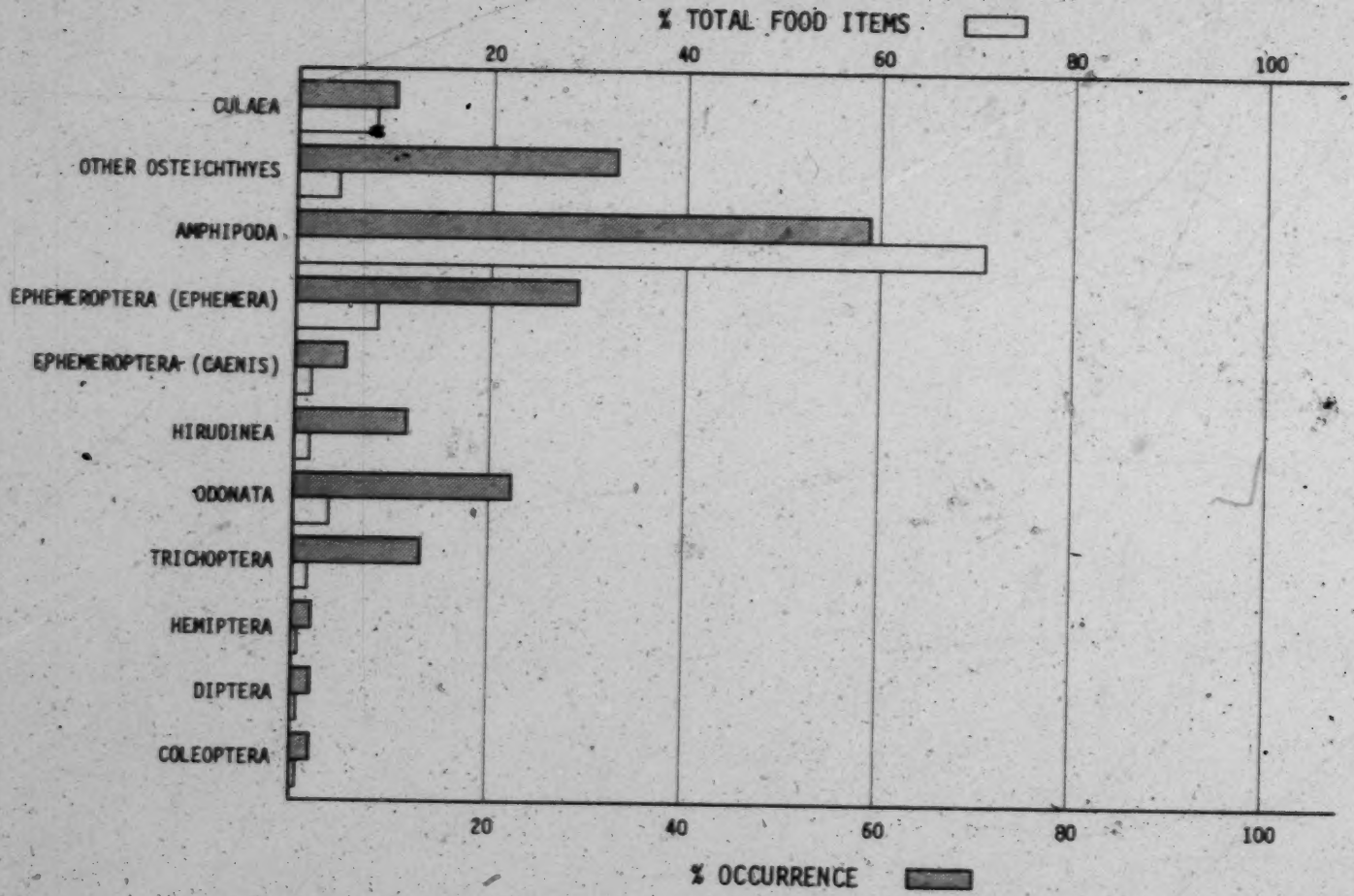


FIGURE 21 WALLEYE - STOMACH CONTENTS: PER CENT OCCURRENCE OF FOOD ITEMS

2. Fishes 42.5% (brook sticklebacks 9.6%)

3. Mayflies 29.1%

4. Damsel- and Dragonflies 12.3%

Other food materials utilized by walleye are leeches, caddis fly larvae, hemipterans, dipteran larvae and coleopterans.

Fish formed 42.5 percent occurrence in walleye stomachs. From those containing identifiable fish brook sticklebacks *(Culaea inconstans)* composed 53.8 percent, walleye *(Stizostedion vitreum)* 17.3 percent, lake whitefish *(Coregonus clupeaformis)* 9.6 percent, yellow perch *(Perca flavescens)* 7.7 percent, spottail shiners *(Notropis hudsonius)* and burbot *(Lota lota)* each forming 5.8 percent of the fish diet.

Sixty-nine percent (675) of the stomachs were found to be empty. The average number of food items per walleye stomach was 15.7.

NORTHERN PIKE *(Esox lucius L.)*

Seibert Lake became well known for its very large pike and this is the reason that Seibert was placed in the trophy lake category. The basic management techniques are thusly directed towards this fish species. The aspects which were studied included growth, abundance of age groups, maturity, spawning, distribution, food and tagging (movements, population size).

Growth

Age was determined with the aid of scales and a few were checked by examination of the hyoid apparatus. Differences in the time in which annuli were laid down were noted in different sized fishes. The smaller or younger pike appeared to show a new annulus as late as middle June while the older and much larger fish formed annuli in late April or early May.

The majority of measurements were taken from angled pike in May and June but few small fish were brought in to be sampled. Thus some of the younger age class measurements are supported by data (lengths) from tagged fish.

The growth of northern pike in Seibert is illustrated in Figure 22 and Figure 23, age versus length and age versus weight respectively. There exists a sexual dimorphism in terms of size between the larger females and the smaller males. The females begin to put on weight and increase in length at a much greater rate than the males at age 4+. Both the males and the females show a reduced rate of growth from age 3+ to 4+; this is related to maturation and will be mentioned in the section on age of maturity.

Trophy pike are determined very subjectively. Some people

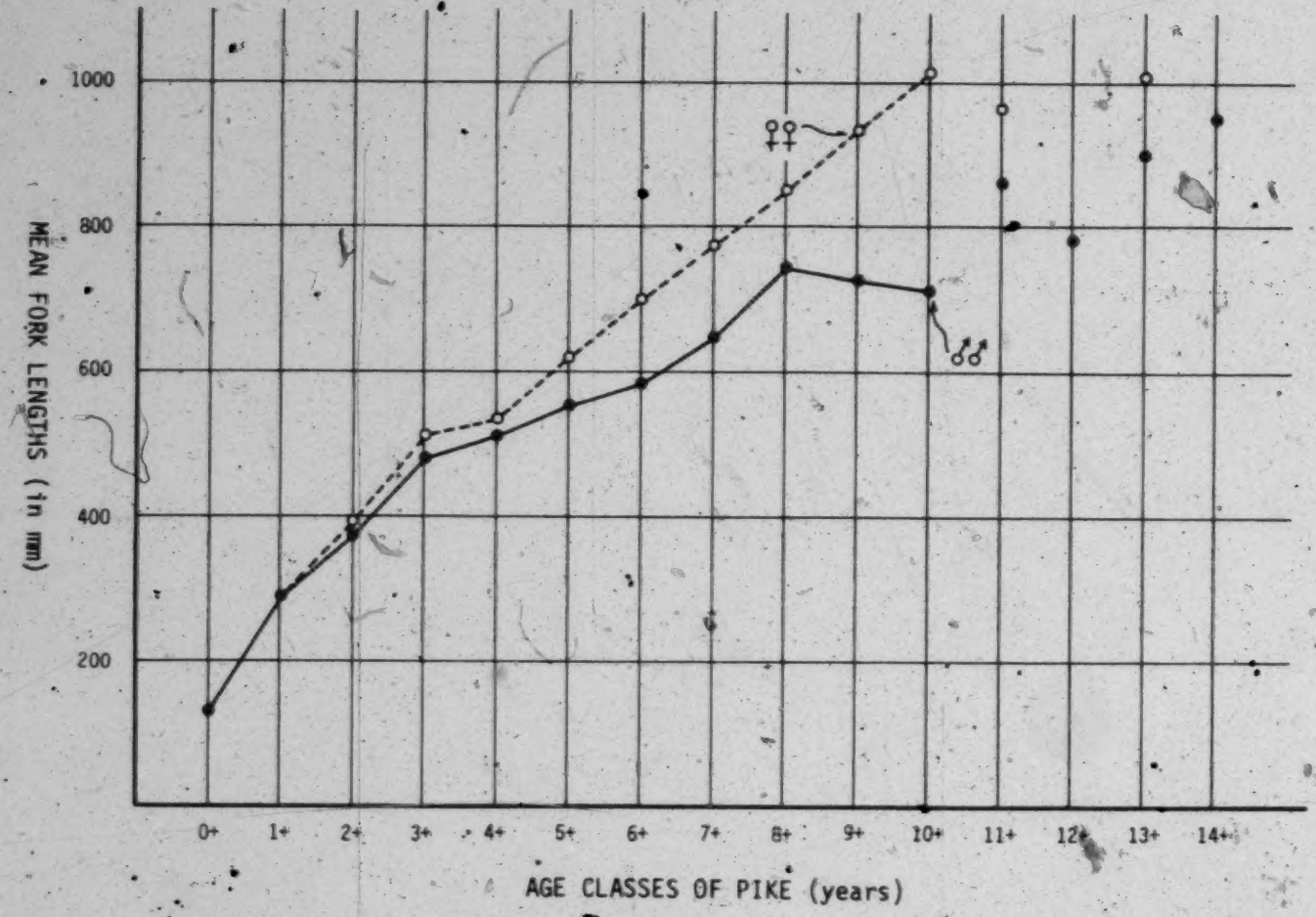


FIGURE 22 NORTHERN PIKE: AGE - LENGTH RELATIONSHIP

(non-connected points indicate small samples)

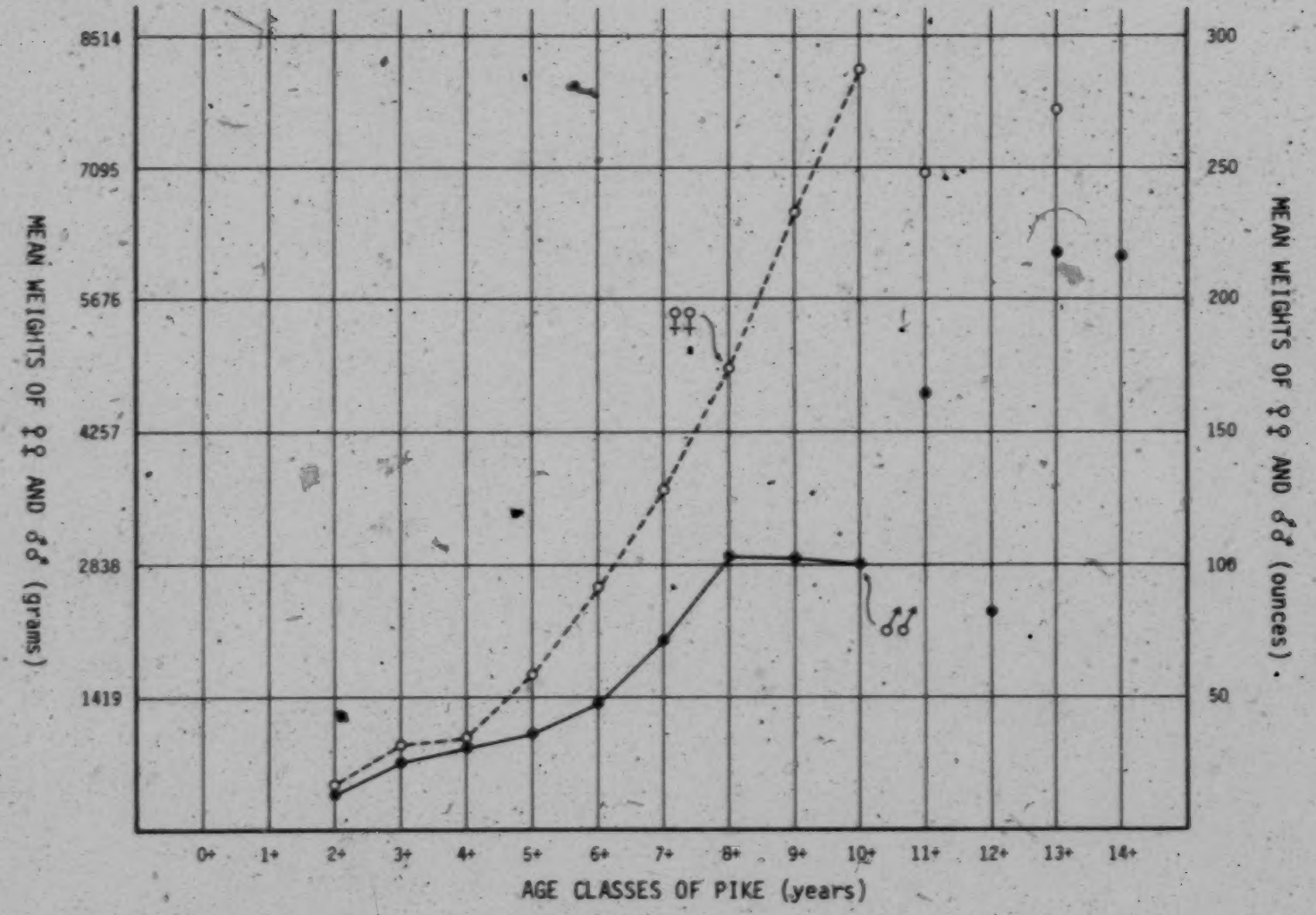


FIGURE 23 NORTHERN PIKE: AGE - WEIGHT RELATIONSHIP

consider a fish over six pounds (2724 grams) as being a trophy; others would accept nothing less than a 15 pound (6810 grams) fish. Most of the trophy fish taken are females. The occasional male greater than 10 years of age was found to be quite large (up to 15 pounds, 6810 grams), but in most cases they appeared to be sterile. In six years a female reaches a total body weight of six pounds (2724 grams). After reaching six years she gains 2.3 pounds (1044.2 grams) to age seven, 2.9 pounds (1316.6 grams) to age eight, 3.6 pounds (1634.4 grams) to age nine and 3.4 pounds (1543.6 grams) to age ten. Very few fish of 11+ and older were sampled.

Appendix XI indicates sample sizes, means, standard deviation and standard errors about the mean of the fork lengths of various age groups. Appendix XII indicates the variation in weights. Generally variation tends to increase with age and thus size. The greatest variation in length where sample sizes were greater than ten was observed in the 8+ males (68.2 mm or 2.7 in.). The range of standard deviations in the length of females was 1.3 inches (33.3 mm) to 2.5 inches (64.3 mm). The standard deviation of weights was greatest in females ranging from 6.2 ounces (177.1 grams) at age 4+ to 49.5 ounces (1406.5 grams) at age 9+.

Variations in weights are generally quite large in large fish and this is partially due to the stomach contents. The overall weight with a large whitefish in the stomach makes for greater variation. The variation in lengths is not exceptionally large.

The oldest pike was a 14+ year old male; the oldest female was 13+ years. The heaviest pike sampled was 26.25 pounds (11917.5 grams) and the longest (fork length) was 44.1 inches (1120 mm).

Length versus weight is plotted in Figure 24. The overall gross slope in grams per millimeter is 12.8.

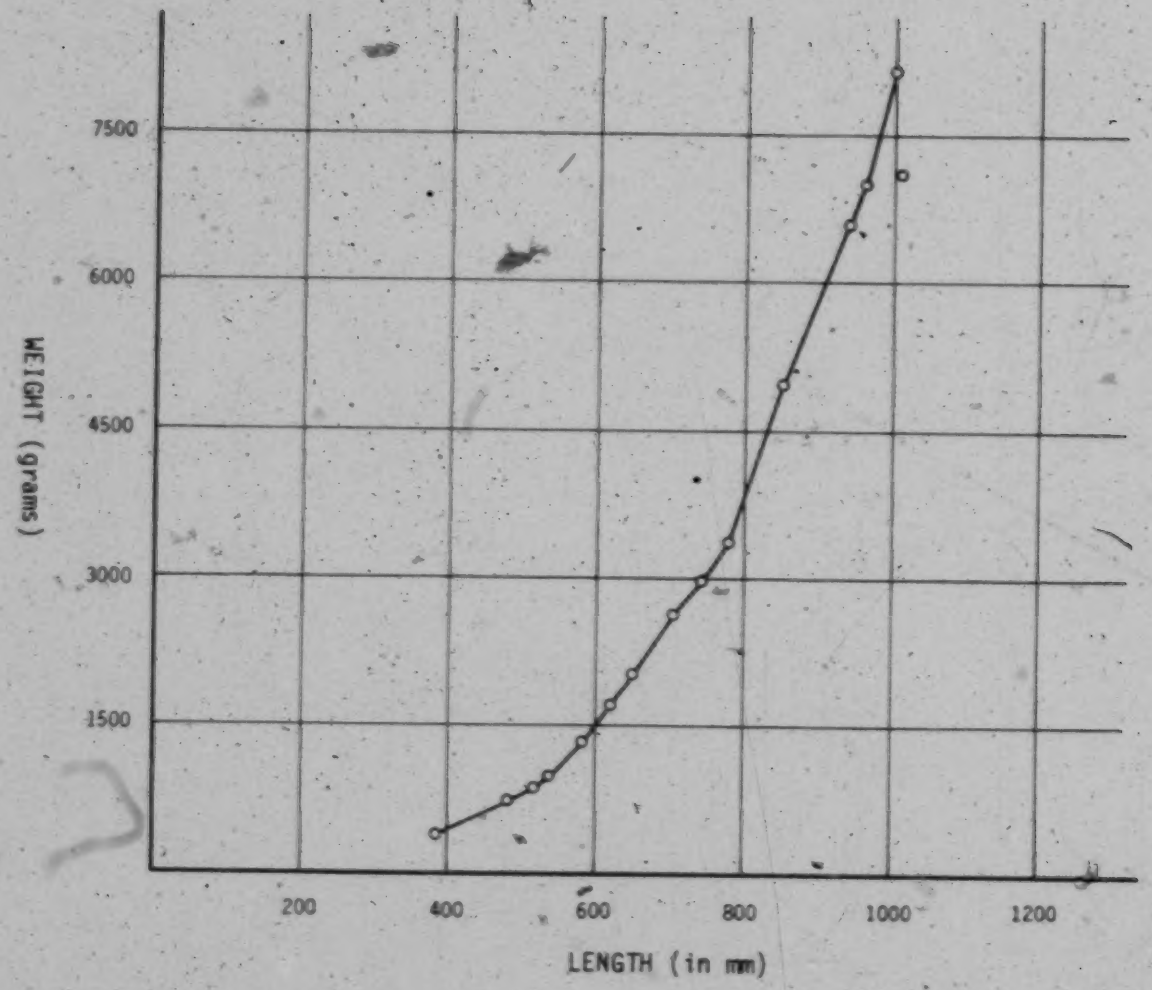


FIGURE 24 NORTHERN PIKE: LENGTH - WEIGHT RELATIONSHIP

The same formula used for the walleye analysis is used to analyze significant differences between means from normal distribution and large sample size.

A comparison of the mean lengths of males and females from age classes 3+ to 10+ is found in Table 12. The analysis indicates significant differences between males and females in the 5+, 6+, 7+, 8+, 9+ and 10+ age classes. Age classes 3+ and 4+ showed no significant growth differences.

Abundance of Age Classes

Figure 25 indicates the abundance of different age classes of angled northern pike. A number of younger age classes (i.e. 3, 4, and 5) were taken as tagged fish and some were collected by angling by the author. Age classes 7+ and 8+ were of greatest abundance in terms of angler catch or angler selection: These two age classes formed 40 per cent of all the pike sampled in 1971-72.

The sex ratio of males to females is 1.0:2.4 in fish sampled by angling. Females form the majority of fish taken especially in age classes 7+ and greater. Females made up 70.4 per cent of all the pike taken.

Distribution of Northern Pike

Anglers were questioned about where they were capturing fish in all years of the study. Appendix XIII shows the locations in which pike have been caught and either retained or released. Figure 26 combines the retained and released numbers into the percentages of fish caught in each of the 14 selected lake zones.

Over 60 per cent of all the pike caught are taken in two areas S 5 and S 13. Over 80 per cent are caught in four areas S5, S 13, S 8

TABLE 12. Statistical differences between mean lengths of male and female northern pike

Age Class	Z Value	Significant Difference (P = .001)
3+	1.20	None
4+	1.54	None
5+	4.27	♀♀ >> ♂♂
6+	6.36	♀♀ >> ♂♂
7+	6.54	♀♀ >> ♂♂
8+	4.51	♀♀ >> ♂♂
9+	6.13	♀♀ >> ♂♂
10+	5.18	♀♀ >> ♂♂

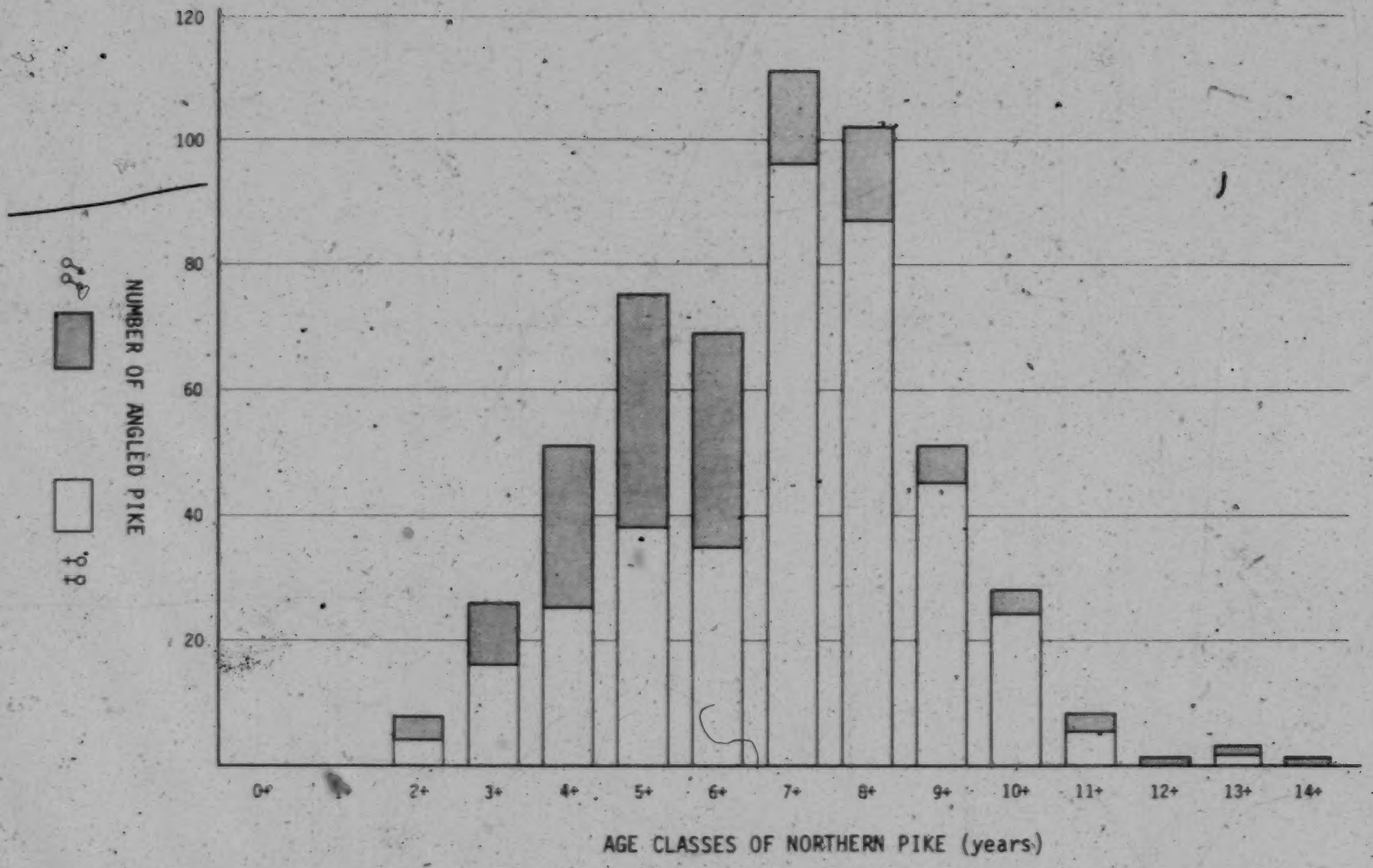


FIGURE 25 NORTHERN PIKE: FREQUENCY OF AGE CLASSES

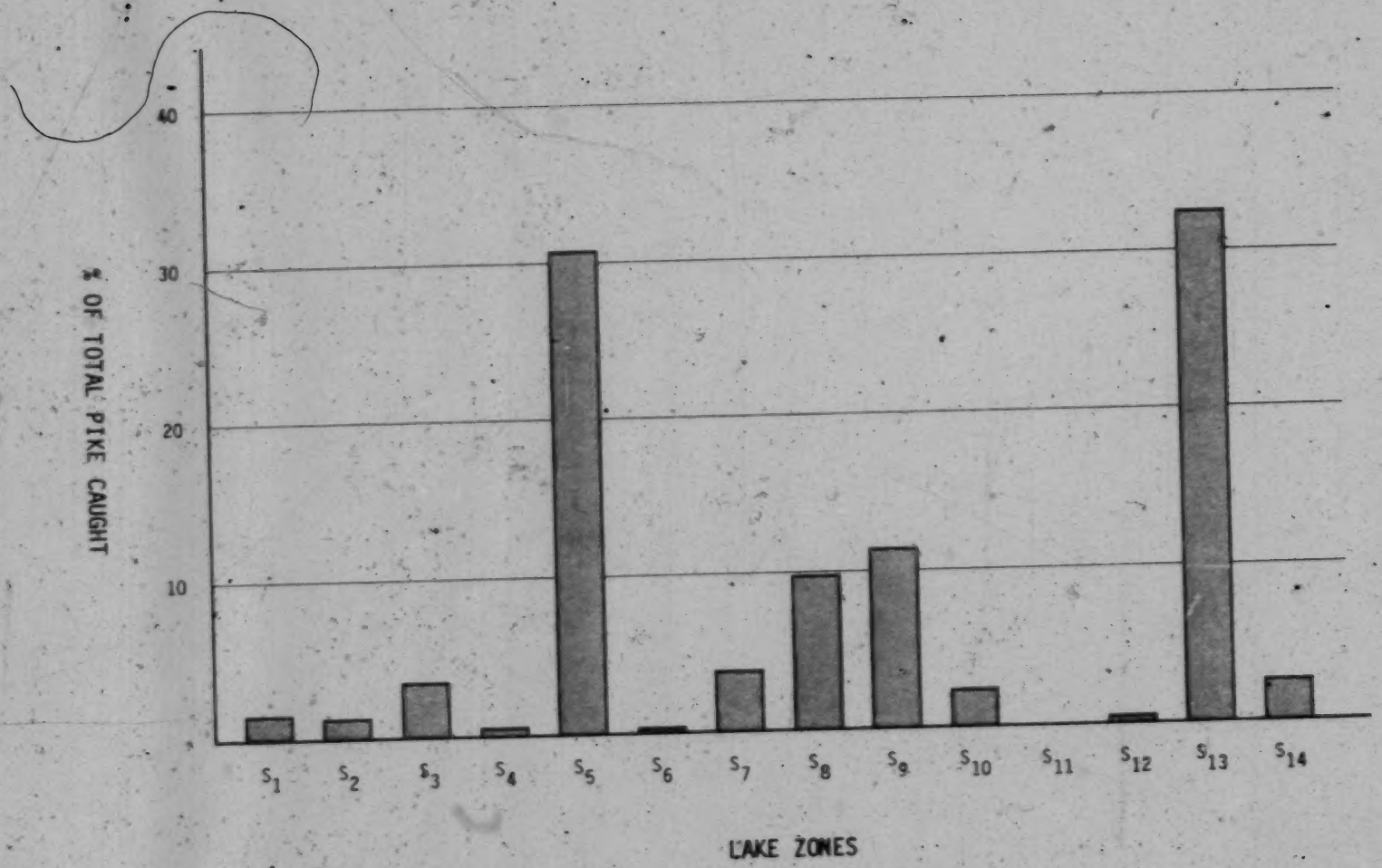


FIGURE 26 . NORTHERN PIKE: LOCATIONAL ABUNDANCE

and S 9. From Figure 26 one notices the areas where very few northern pike are taken, these include S 4, S 6, S 11 and S 12.

Of all the pike caught in 1971-72 (2876) 21.2 per cent were retained. This means that approximately one out of every five fish caught is retained.

Figure 27 compares the actual numbers of pike released and retained in the different lake zones.

Age Structure of Pike Captured in Different Lake Zones

Table 13 shows the mean lengths, mean weights, mean ages and sex ratios of pike retained in different parts of the lake. The differentes in areas S 5 and S 13 are greatest from other parts of the lake in that the average fish taken out is much larger and older. Also of note is the sex ratio which is heavily slanted towards the female side in S 5 and in S 13.

Figure 28 is a graph comparing the mean lengths and mean ages of pike from different parts of the lake. This information should not be misinterpreted since a great many more fish are released than retained particularly in S 5 and S 13. The zonal differences in age and size do tell us that there are differences in population structure and population size from area to area but the degree of difference shall be discussed in a later section.

But the portion of the lake where anglers are taking trophy pike appears to be limited.

Maturation and Spawning

Maturity of pike was difficult to assess since access to the lake was difficult during the winter and in the early spring (before

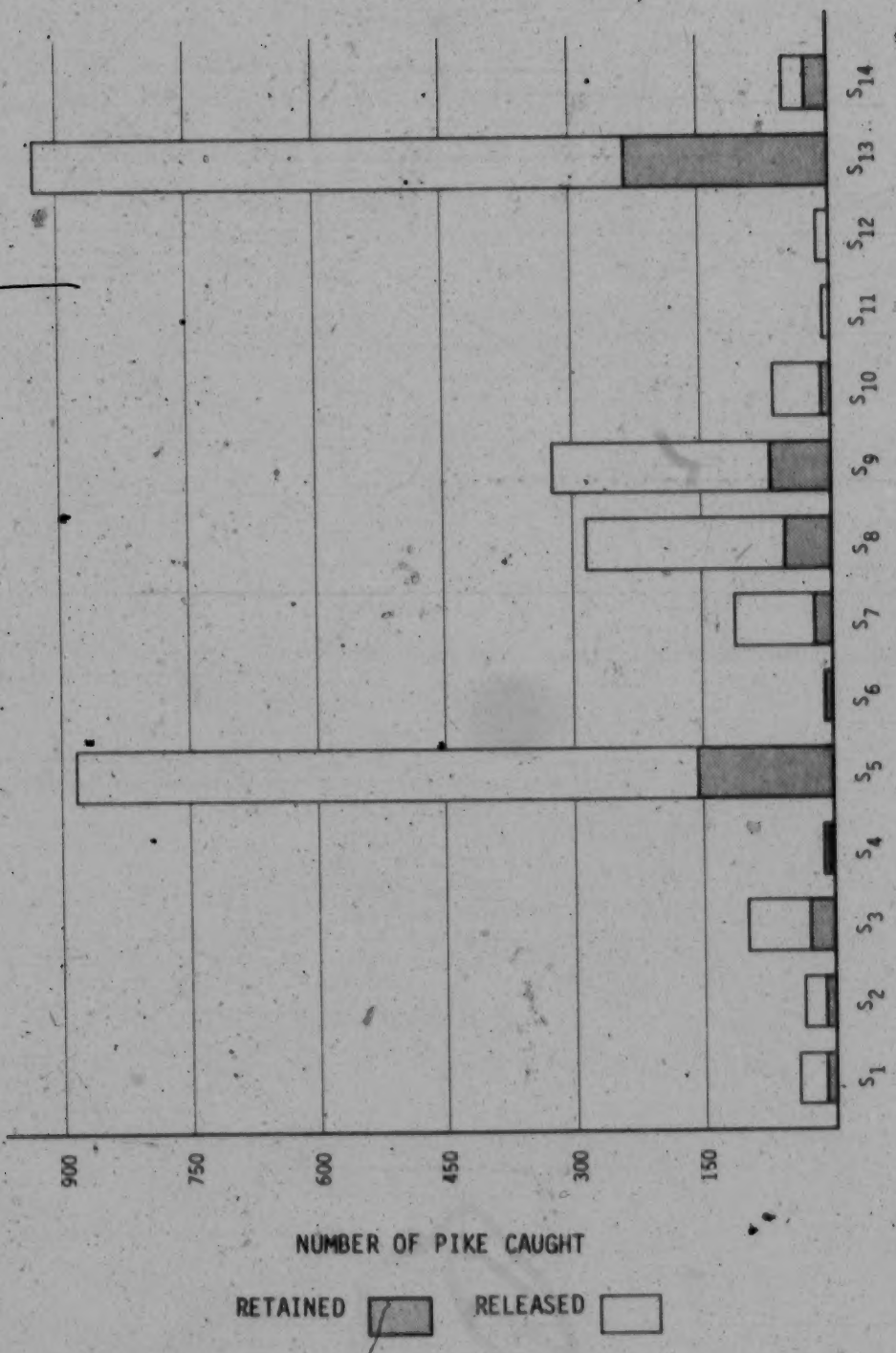


FIGURE 27 LAKE ZONES WHERE PIKE ARE RETAINED AND RELEASED

TABLE 13. Size and age of northern pike in different areas of the lake

Lake Zone	Number of Pike Retained	Mean Age (yr)	Mean Length (mm)	Mean Weight (gm)	Ratio ♂ : ♀
S 1	8	4.1	567.3	1048.0	3:5
S 2	10	4.6	575.0	1459.8	5:5
S 3	27	4.8	562.3	1411.5	15:12
S 4	2	3.0	456.5	667.4	1:1
S 5	135	7.8	814.9	4603.6	20:115
S 6	3	4.3	576.0	1249.6	2:1
S 7	17	5.5	650.0	2746.3	5:11
S 8	45	5.7	627.6	1985.2	23:22
S 9	64	6.0	676.7	2587.2	22:42
S10	8	5.4	677.9	2328.8	5:3
S11	0	-	-	-	-
S12	2	5.5	563.0	1334.8	2:0
S13	188	7.3	769.0	3834.0	37:151
S14	25	5.2	586.7	1522.2	16:7

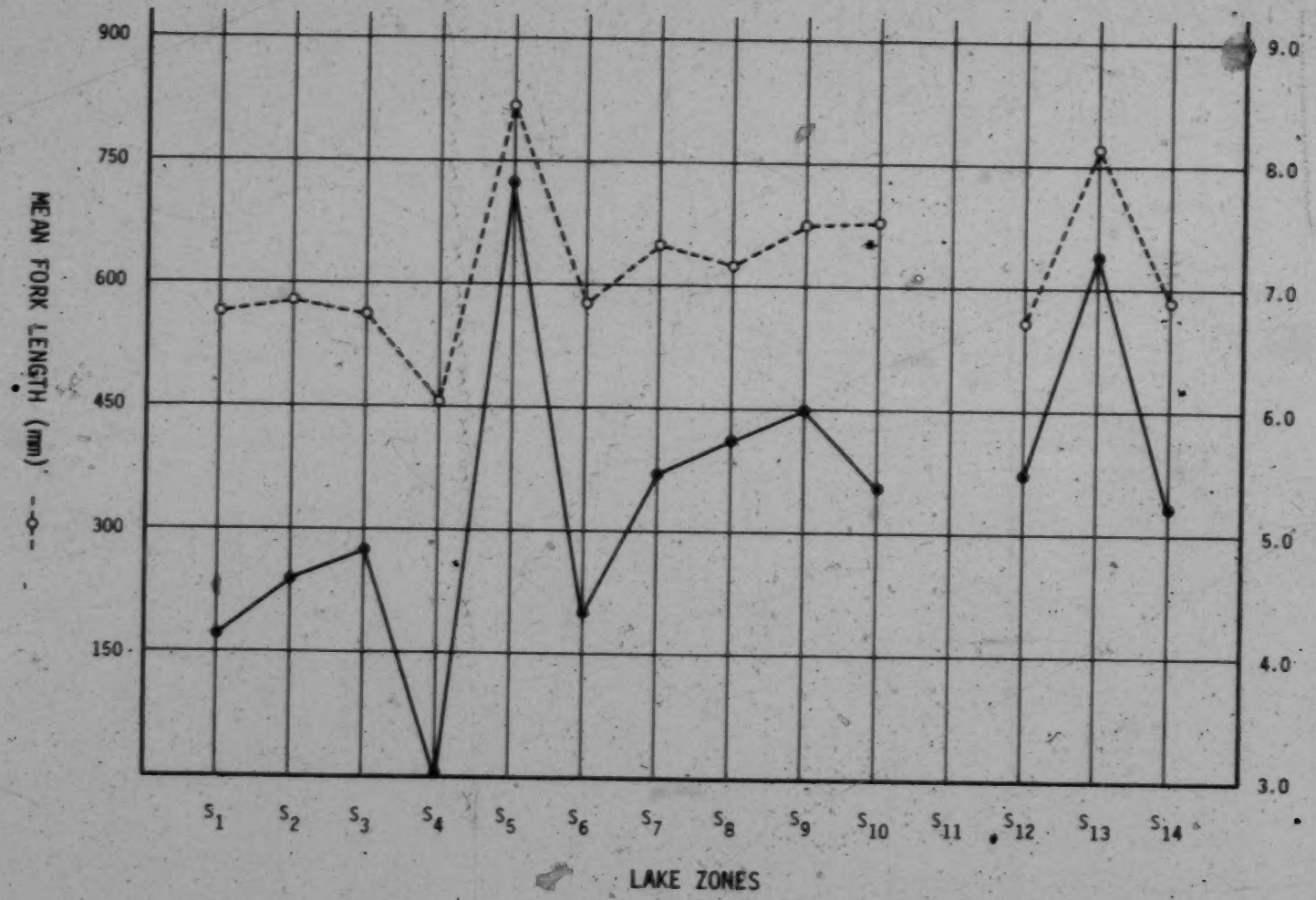


FIGURE 28 MEAN LENGTH AND AGE OF PIKE IN DIFFERENT PARTS OF THE LAKE

spawning). But pike were sampled in the fall and in most cases one could determine whether the gonads would develop for the spring spawn. Pike sampled in May could also be evaluated to whether they were immature or spent. Table 14 compares males and females and their maturation age. Males are found to mature earlier than females; all males are mature at 3+, while only a few females are mature at 3. Both sexes are mature at 4. The growth curve previously described indicated a reduced rate of growth between age 3+ and 4+ (especially for females), this probably is a result of the first year in which gonads develop.

An interesting observation was that some of the younger females (aged 4 and 5) remained ripe until late May and early June. Four fish were recorded in this state while virtually 100 per cent of the other pike (especially the large pike) were finished spawning by May 5.

Spawning of northern pike in Seibert Lake is confined to the lake since no major streams enter the lake. Four areas were observed as having good spawning grounds with actively spawning fish. Two areas S 13 bay and S 5 bay were the two prime zones with quite large suitable areas (Photograph 8). Two other areas, S 8 and S 9 with limited spawning habitat, were active sites as well. Spawning probably occurs throughout the lake shoreline but with very limited success because of the limited habitat.

Actual spawning areas contained mats of various vegetation types. The types of vegetation included some submergent types (*Myriophyllum*, *Potamogeton zosteriformes* and *Drepanocladus*) but mainly the submerged emergent types (*Carex*, *Scirpus* and *Eleocharis*). Spawning occurs in very shallow water usually over a mat of vegetation from the last year's growth.

Pike were observed thrashing over sticks and dead *Scirpus* in S 2 before the ice had left the lake (early May). Young of the year pike

TABLE 14. Age of maturity of northern pike in Selbert Lake

Age Class	Males	Females
0+	Immature	Immature
1+	Immature	Immature
2+	Immature	Immature
3+	Mature	Some Mature (few)
4+	Mature	Mature

Photograph 8. S13 bay is an area in which spawning occurs. Note the flooded vegetation. This is a photograph taken in early May.

(0+) were seined in S 3, S 6 and S 7 on sand-gravel bottoms with very limited vegetation. These are indicators that pike have been spawning in many parts of the lake.

Food of Northern Pike

The food of northern pike in Seibert Lake was determined from the analysis of 479 stomachs, all of which were taken from pike captured in the spring or summer of 1971-72. The percentage occurrence of food items is charted in Figure 29. The major items found in the diet of pike are: lake whitefish 55.1 per cent, amphipods 18.1 per cent, brook sticklebacks 8.7 per cent and unidentifiable fish 18.1 per cent. Only 9.8 per cent of the pike had food other than fish.

Table 15 indicates all the food items that have been found in pike as well as the total numbers and mean numbers per pike. Amphipods and brook sticklebacks when present in a stomach are most abundant in that the average number per pike is 17.6 and 9.0 respectively. All other food items when utilized are present in numbers less than two. Most fish food items average 1.0 fish per pike stomach. In this respect the average number of food items per pike stomach is 5.3. This number decreases with an increase in size which means that large pike have very few items in their stomachs. The number of feeding pike with more than one food type is 17.7 per cent.

Table 16 and Figure 30 show the sizes of fish eating different food items. The average size of a pike feeding on lake whitefish is 31.5 inches (800.9 mm) and weighs 9.4 pounds (4272.1 grams). Pike eating all other food items (except other fish) are less than 23.6 inches (600 mm) and less than 3 pounds (1362 grams).

Eyed eggs of brook sticklebacks were observed in five pike

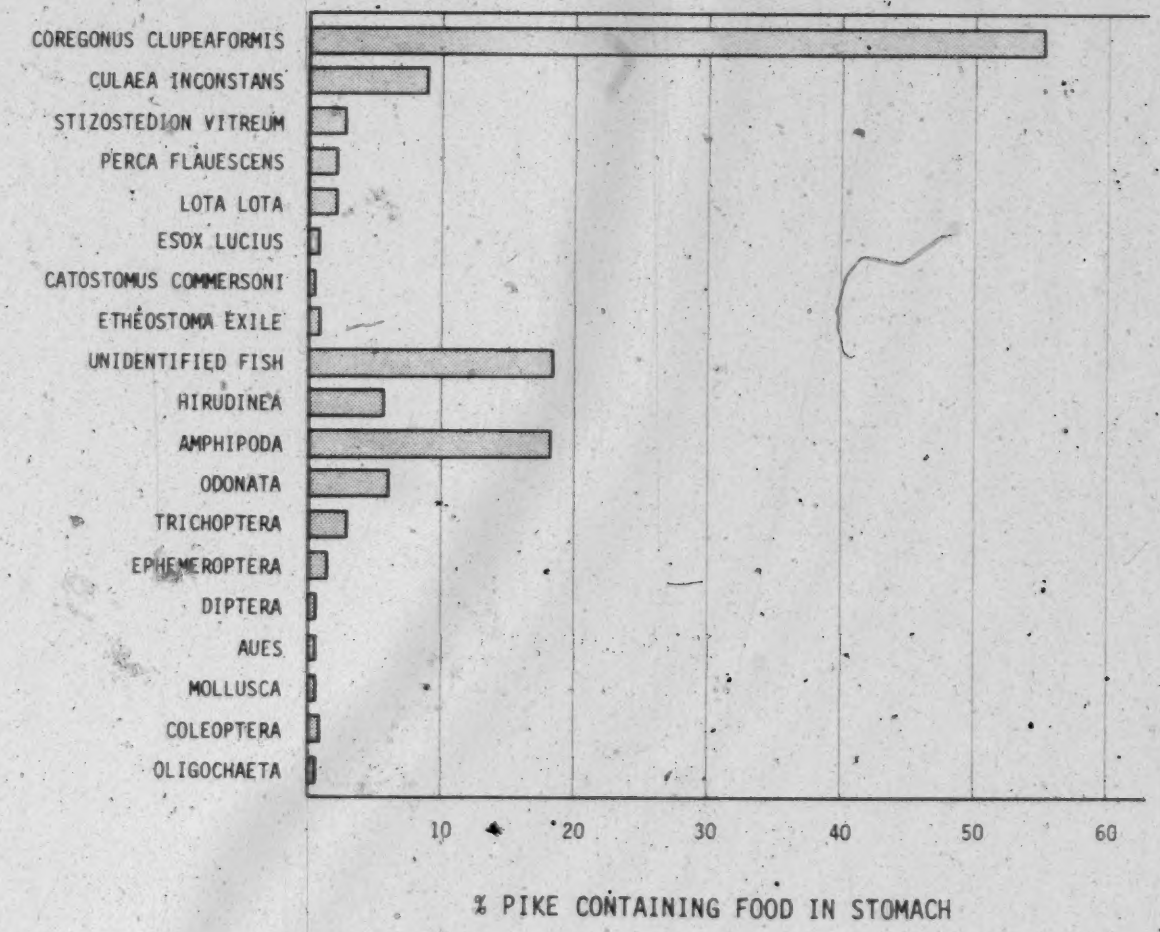


FIGURE 29 PIKE STOMACH CONTENTS

TABLE 15. Northern pike stomach contents

Stomach Contents	Number of Pike	Percent of Total Checked	Percent Occurrence	Total Number of Organisms	Mean Number per Fish
Osteichthyes					
Coregonus clupeaformis	140	29.2	55.1	142	1.0
Culaea inconstans	22	4.6	8.7	198	9.0
Stizostedion vitreum	7	1.5	2.8	7	1.0
Perca flavescens	5	1.0	2.0	5	1.0
Lota lota	5	1.0	2.0	6	1.2
Esox lucius	2	0.5	0.8	2	1.0
Catostomus commersoni	1	0.2	0.4	1	1.0
Etheostoma exile	2	0.5	0.8	3	1.5
Unidentified	47	9.8	18.5	89	1.9
Hirudinea	14	2.9	5.5	22	1.6
Amphipoda	46	9.6	18.1	806	17.6
Gammarus					
Odonata	15	3.1	5.9	29	1.9
Lestes, Macromia Aeschna					
Trichoptera	7	1.5	2.8	11	1.6
Phryganea					
Ephemeroptera	3	0.7	1.2	9	3.0
Ephemera					
Coleoptera	2	0.5	0.8	4	2.0
Dytiscus					
Diptera	1	0.2	0.4	4	4.0
Tendipes					
Oligochaeta	1	0.2	0.4	1	1.0
Mollusca	1	0.2	0.4	2	2.0
Aves (duckling)	1	0.2	0.4	1	1.0
No. Containing Food	254	46.9		1342	5.3
Empty	225				

TABLE 16. Size of pike eating certain food items

Food Items	Number of Pike	Mean Weight of Pike (gm)	Weight Range	Mean Length of Pike (mm)	Length Range
Lake whitefish	140	4272.1	965.6-8633.6	800.9	462-1099
Brook stickleback	22	945.7	568.0-1278.0	528.1	420-600
Amphipoda	46	959.9	511.2-1448.4	530.7	423-600
Odonata	15	1297.9	795.2-3521.6	576.0	500-815
Hirudinea	14	852.0	397.6-3521.6	481.5	380-600
Items other than fish	25	1130.3	397.6-1334.8	550.6	380-815

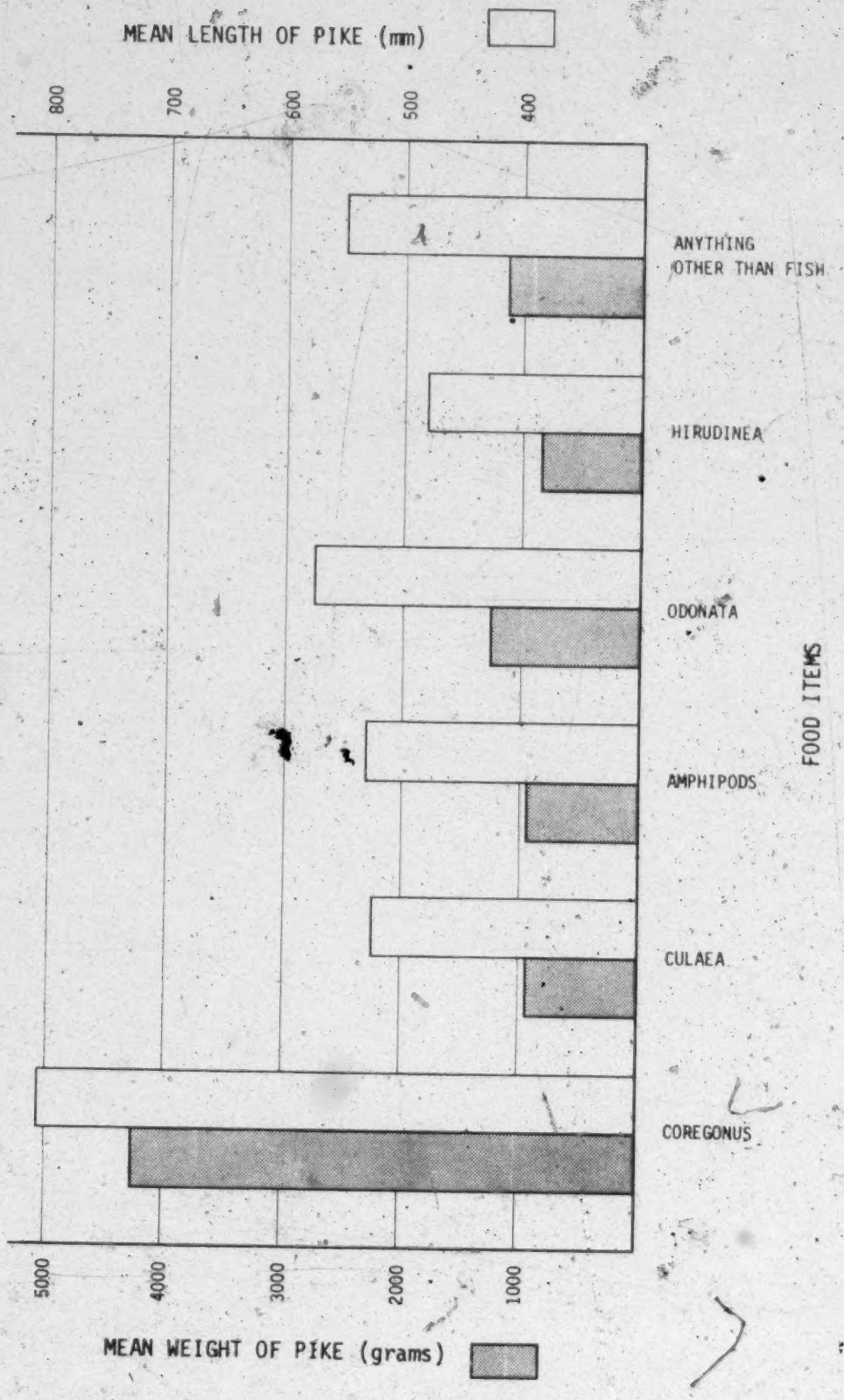


FIGURE 30. NORTHERN PIKE: SIZE OF PIKE EATING CERTAIN FISH ITEMS

stomachs. In one case an intact nest with the eggs was found in a stomach. In only one case was a brook stickleback found in a stomach containing eggs.

Lake Whitefish as a Major Food Item of Northern Pike

The relationship between the lake whitefish of Seibert Lake and the northern pike could readily be witnessed by observing *Triaenophorus crassus* in lake whitefish. A very high incidence of *T. crassus* of 349.2 cysts per one hundred pounds indicates a very close predator-prey relationship between pike and whitefish.

To better understand the relationship between lake whitefish and northern pike the whitefish found in stomachs were measured, weighed and aged when scales were available. Since whitefish were found to occur in at least 55.1 per cent of the stomachs that had food and in at least 90 per cent of the pike over six pounds (2724 grams) in weight, it seems necessary to look at the average size of whitefish taken as well as the age classes being used by pike.

Figure 31 shows the numbers of whitefish of various age classes sampled from pike stomachs. It shows that the major age classes of whitefish found in pike stomachs are: 5+ (12.8%), 6+ (25.6%), 7+ (35.9%), 8+ (10%) and 9+ (6.4%). Thus 93.5 per cent of the whitefish are five years of age and older and this seems to indicate that pike are "harvesting" the older age classes of whitefish.

The stage of digestion prevented accurate determination of size of lake whitefish but by utilizing data from whitefish taken in gill nets (Figure 9) the mean sizes of age classes can be determined. The average size of whitefish in pike stomachs was 26.9 ounces (764.0 grams) and 14.8 inches (375 mm). Only 6.5 per cent of the whitefish are of a

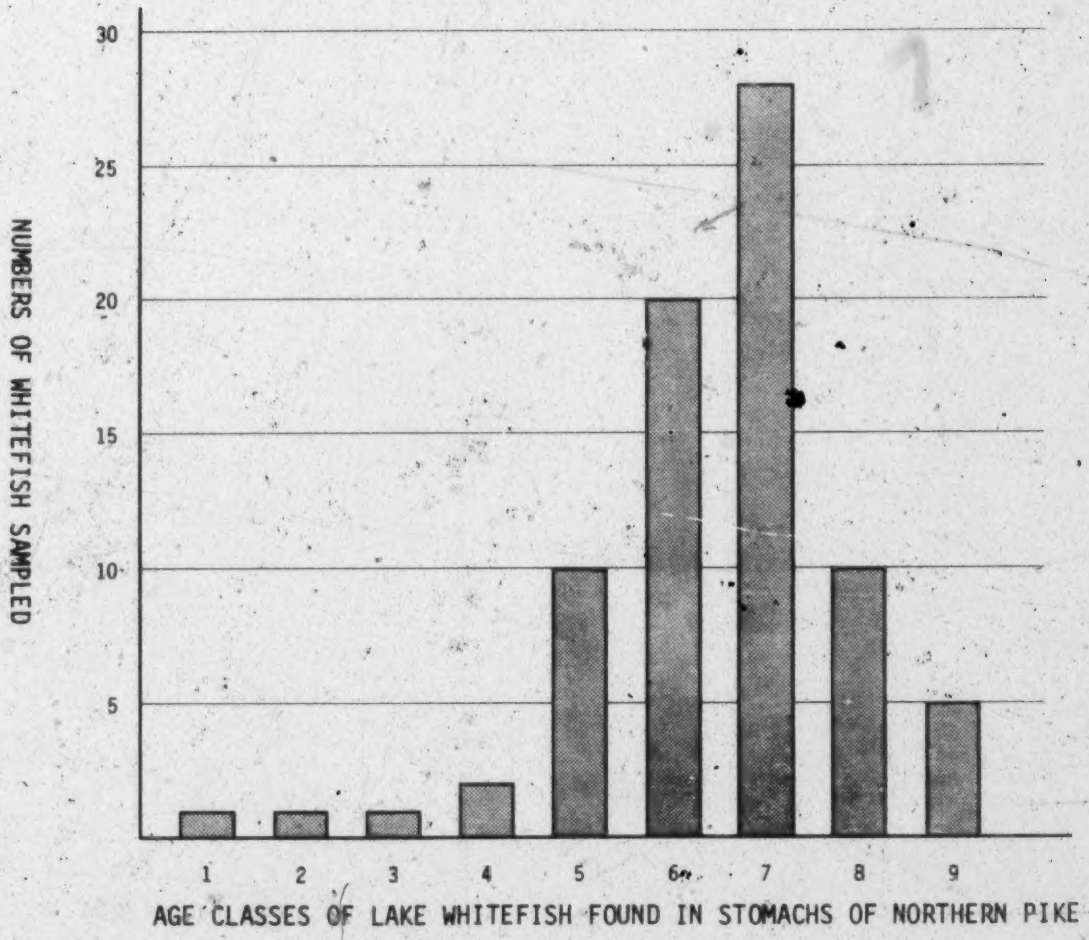


FIGURE 31 STOMACH CONTENTS OF PIKE: FOOD ITEM LAKE WHITEFISH

weight less than 24.6 ounces (698.6 grams) and a length of less than 14.0 inches (356.7mm.)

Most whitefish were found to have been taken head first (Photograph 9). Photograph 10 shows a stage of digestion of a whitefish found in a pike stomach.

Tagged Northern Pike

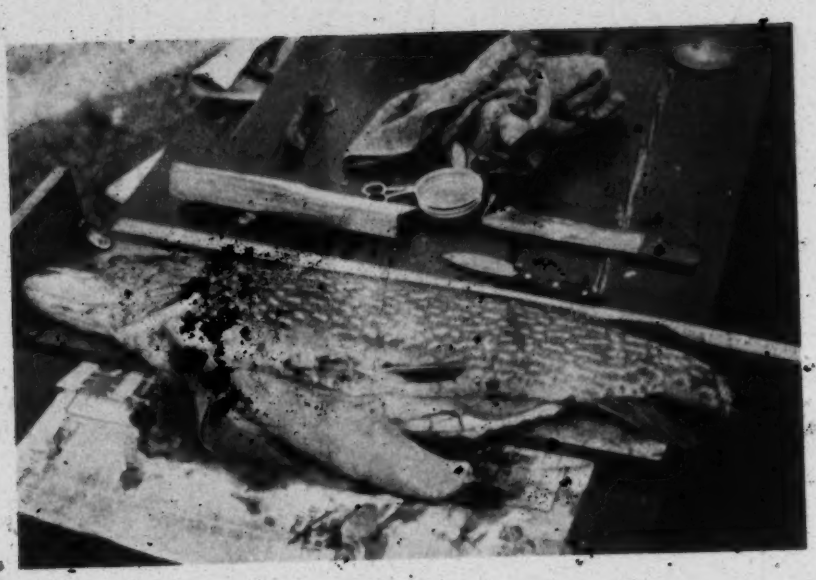
Tagging was carried out in all parts of the lake during the spring-summers of 1971 and 1972. A total of 663 northern pike were tagged with numbered spaghetti tags. A complete list of tagged fish with tag numbers, sizes, ages, locations and dates is found in Appendix III (A) and (B).

A number of figures will be shown which may act as a comparison with the angler caught northern pike. Included in this section will be growth, age class distribution, numbers in different lake zones and characteristics of pike from different lake zones. The information derived from tagged fish must be treated with caution in that males are not distinguished from females, everything caught was tagged and tagging was basically limited to July and August thus few large trophy pike were tagged.

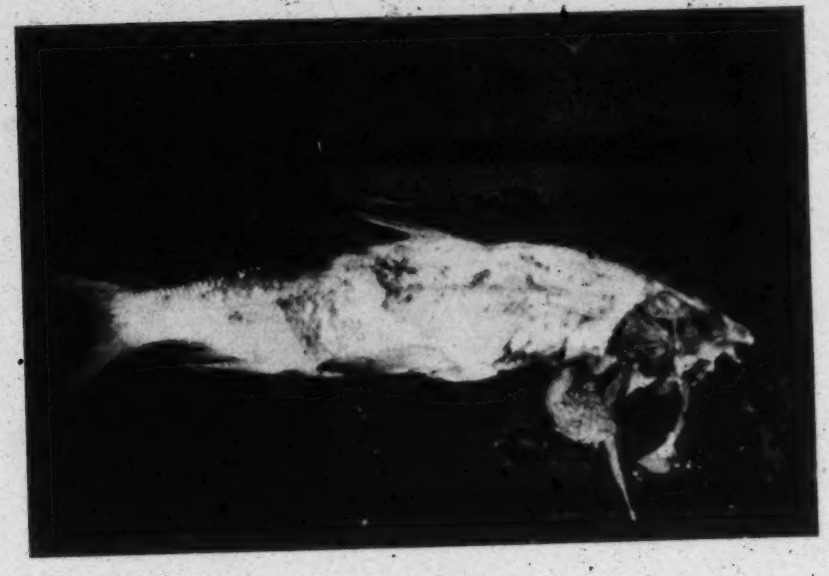
In a later section the results of tagging returns and population estimation will be presented.

(a) Age Class Distribution and Size

Figure 32 shows the numbers of tagged pike of particular age classes. The dominant age classes are 3+ (23.1%), 4+ (21.6%) and 5+ (18.9%); the three age classes form 63.6 per cent of the total fish tagged. The mean age of all the tagged fish was 4.09. The oldest pike tagged was 11+.



Photograph 9. Northern pike with lake whitefish in the stomach. Note that the whitefish was taken head first. The size of the pike is 14 pounds and the whitefish is 1.5 pounds.



Photograph 10. Stage of digestion of lake whitefish found in pike stomach.

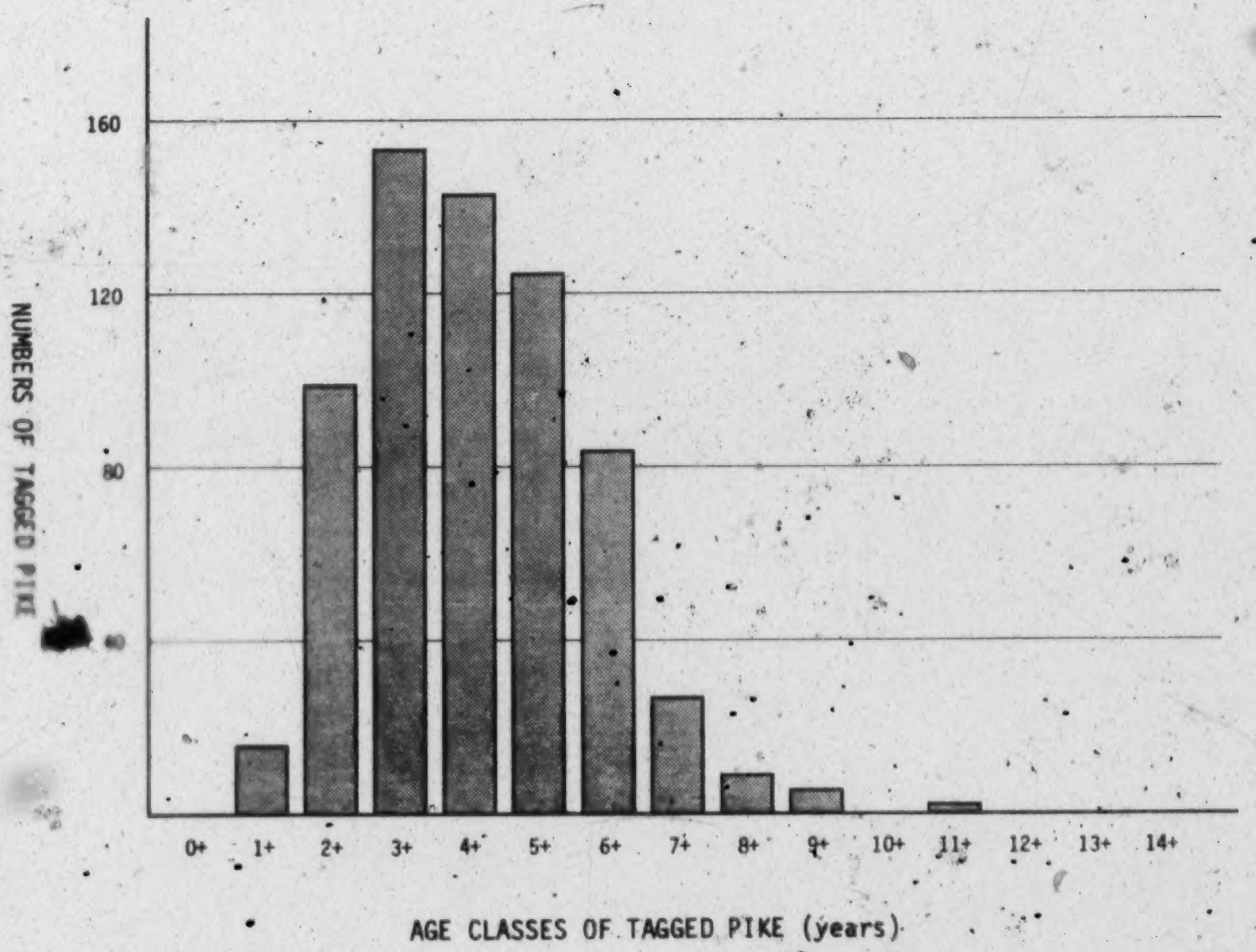


FIGURE 32 • NUMBERS OF TAGGED PIKE OF PARTICULAR AGE CLASSES

Figure 33 shows the mean length of various age classes of tagged pike. These pike are of undefined sex thus by comparing this graph with Figure 22 one notices that the mean lengths of tagged pike fall between mean lengths of males and females at a particular age. The largest pike was 41.3 inches (1050 mm).

Appendix XIV indicates the variation of fork lengths in tagged pike. Generally the variations (standard deviations) are larger than those found in males or females of angler caught pike which is to be expected. Variation increased with age to a maximum of 7.9 inches (201.8 mm) with sample size of 5 at age 9+. The maximum standard deviation from angler caught pike was in age 8+ males 2.7 inches (68.2 mm).

(b) Distribution of Tagged Pike and Characteristics of Pike in the Different Lake Zones

Table 17 indicates the locational differences between tagged pike; it also shows the numbers and percentages of tagged pike taken in different lake zones. The numbers of pike tagged in each of the sampling areas (lake zones) is charted in Figure 34. An initial attempt was made at maintaining equal numbers of tagged pike and more or less equal time and effort in all fourteen zones but seemingly small populations in some zones did not permit this attempt. The figure indicates that five areas, S 3, S 5, S 8, S 9 and S 13, had approximately equal numbers (90-125) of tagged fish. Very few fish were tagged in S 1, S 4, S 6, S 11 and S 12. Intermediate numbers (>20<40) were tagged in S 2, S 7, S 10 and S 14.

Figure 35 compares the mean lengths and mean ages of pike tagged in the fourteen lake zones. The mean lengths do not fluctuate from area to area to any great extent but note the differences between mean age and mean length of particular zones: For example in S 7 and S 9 the growth

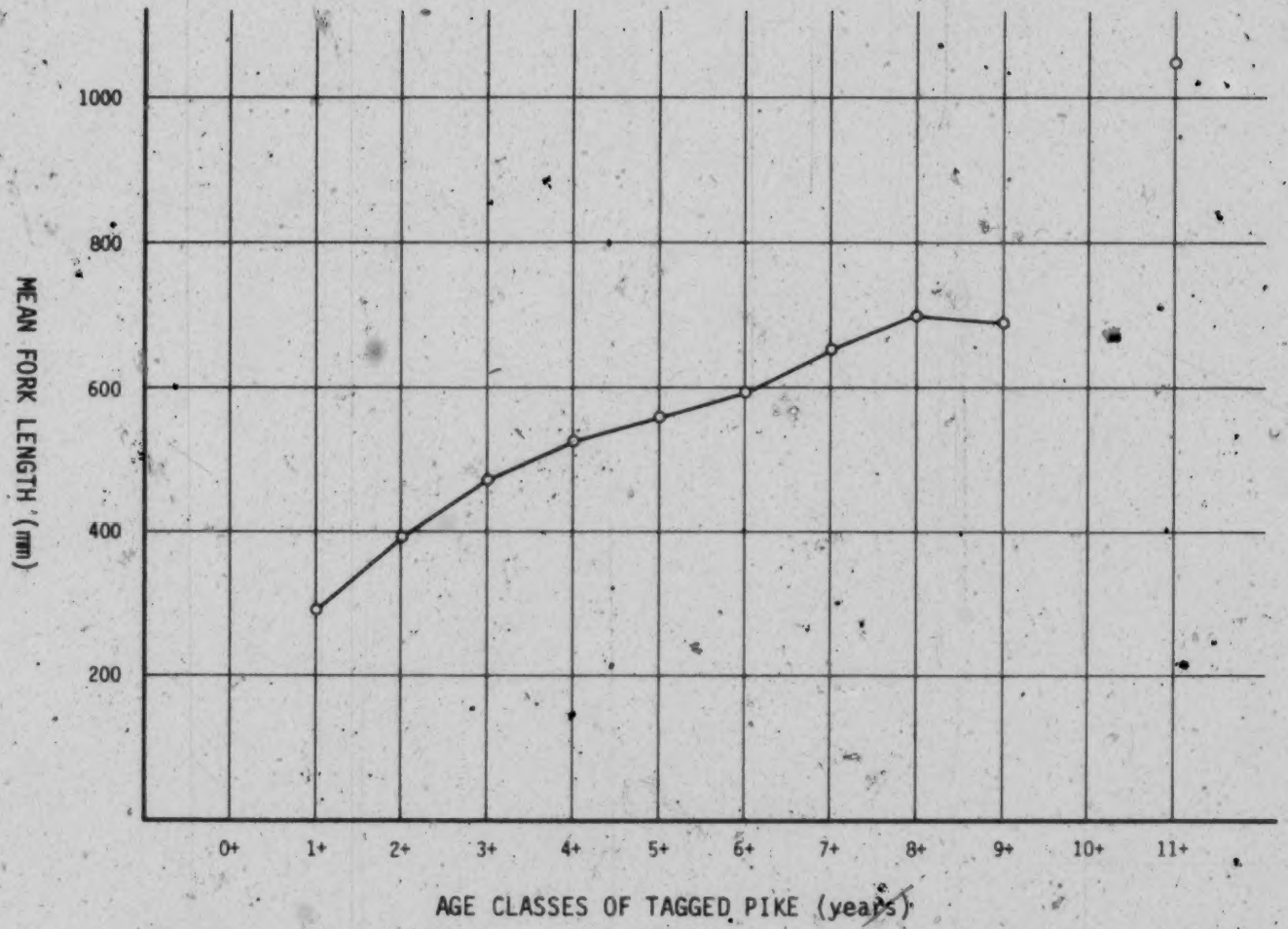


FIGURE 33 TAGGED PIKE: AGE - LENGTH RELATIONSHIP

TABLE 17. Locational differences of tagged northern pike

Lake Zone	Number of Tagged Fish	Percent of Total	Mean Age (years)	Mean Length (mm)
S 1	9	1.4	4.4	553.1
S 2	35	5.3	3.5	500.0
S 3	90	13.6	3.8	504.1
S 4	7	1.1	2.9	434.3
S 5	103	15.5	4.6	552.0
S 6	3	0.5	3.0	406.0
S 7	36	5.4	3.6	509.1
S 8	97	14.6	3.9	513.6
S 9	100	15.1	4.2	538.0
S10	23	3.5	4.3	564.0
S11	0	-	-	-
S12	8	1.2	4.4	546.8
S13	125	18.9	4.2	489.0
S14	26	3.9	4.1	480.1

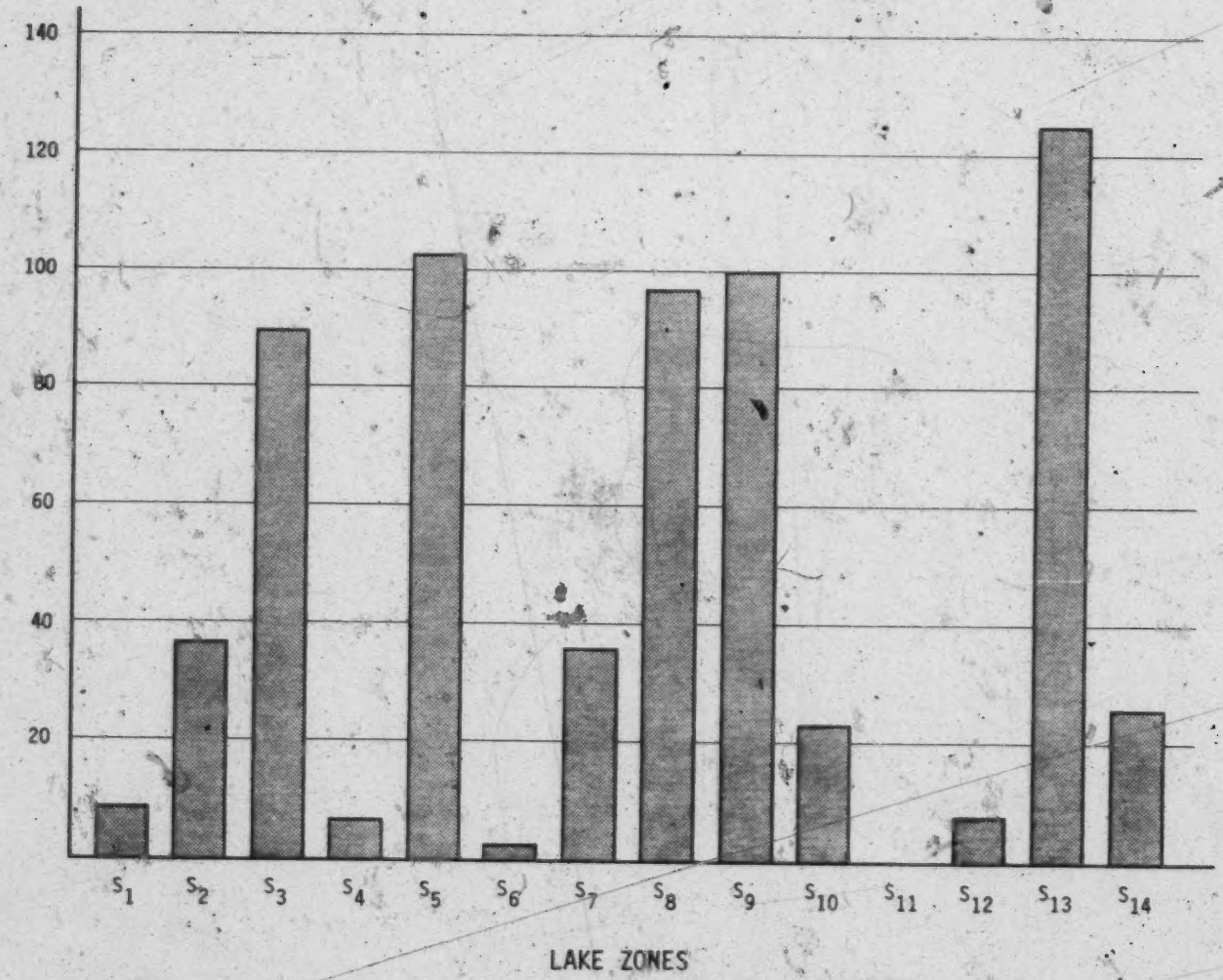


FIGURE 34 NORTHERN PIKE: NUMBERS OF TAGGED PIKE IN DIFFERENT AREAS

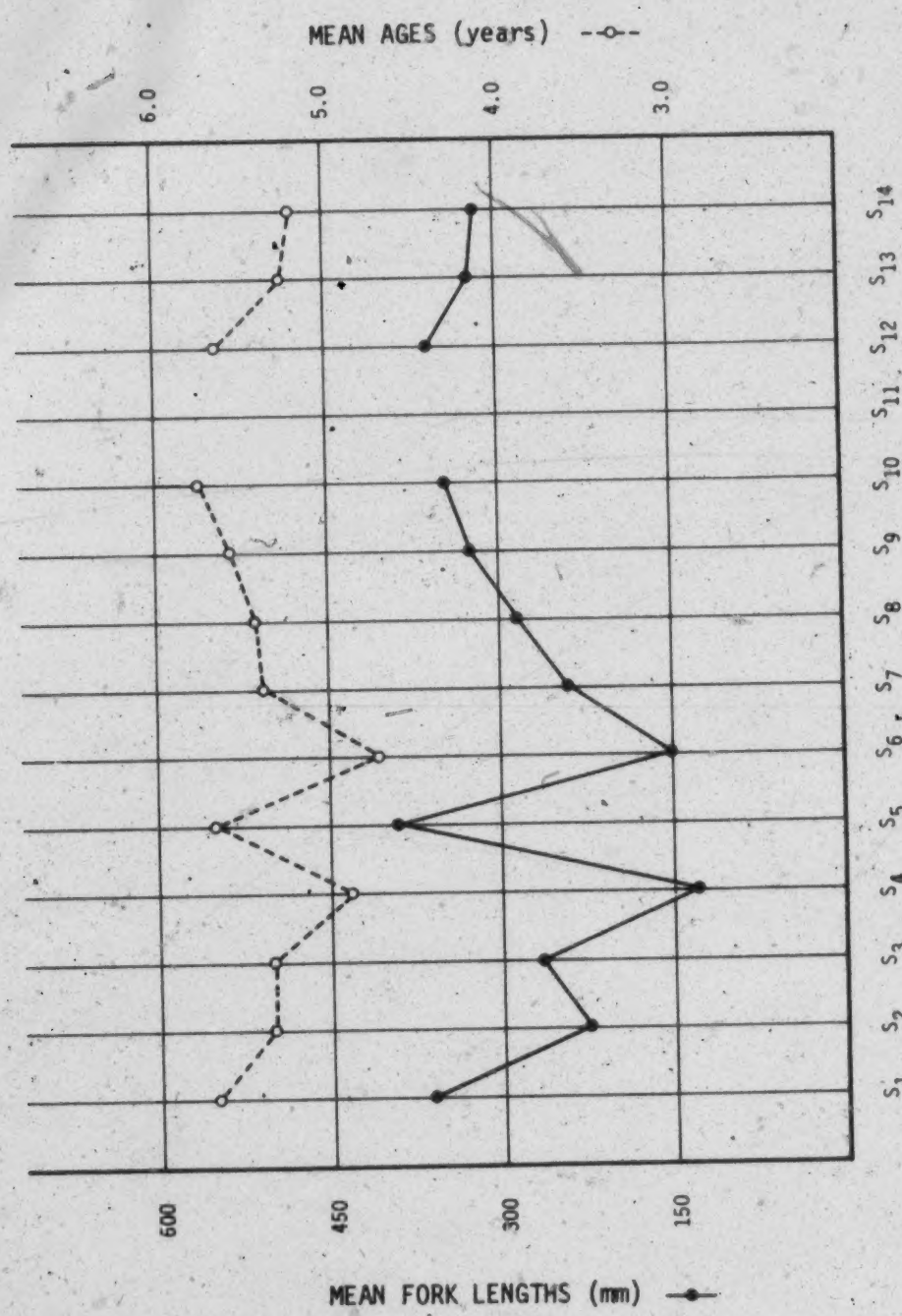


FIGURE 35 TAGGED PIKE: MEAN AGES AND LENGTHS

rate is quite rapid where as in S 5, S 13 and S 14 the growth rate is much slower.

Zone	Mean Age (yrs)	Mean Length (mm)	Length/Age
S 7	3.6	509.1	141.8
S 9	4.2	538.0	129.0
S 5	4.6	552.0	120.0
S 13	4.2	489.0	117.8
S 14	4.1	480.1	116.8

In the above chart the length/age column indicates the difference in the rate of growth. The difference in particular between S 7 and S 14 was very noticeable when reading scales in the determination of fish ages. The distances between annuli were quite large in pike from S 7 as compared to those from S 14.

The range in mean ages was 2.9 to 4.6 while the range in mean lengths was 406.0 to 564.0 mm..

The statistical analysis of specific age classes of pike from different lake zones is indicated in Table 18. The analysis of lengths of certain age classes from different lake zones was carried out using the students "t" distribution which considers the mean lengths of two zones, standard deviation and sample size. The value of "t" indicates the degree of similarity between the means. The higher the vaules of "t" the greater the difference between the means.

Table 18 shows that S 7, S 8 and S 9 show quite similar growth patterns for age classes 3+, 4+ and 5+. Pike at age 3+ in S 7 are significantly larger than those in S 5, S 13 and S 14. The pike from S 14 are slow growing and this is noted in older age classes. The 5+ pike from S 14 are significantly smaller than those from S 7 and as S 14 pike age, growth appears to be retarded.

TABLE 18. Statistical differences in growth of northern pike from different zones of Seibert Lake.

Age Classes	"t" values of length comparison between various zones				
	S 7 : S 5	S 7 : S13	S 7 : S14	S 7 : S 8	S 7 : S 9
3+	6.11 S 7>>S 5	6.55 S 7>>S13	3.80 S 7>S14	2.83 similar	1.12 similar
4+	2.62 similar	1.74 similar	.17 similar	.31 similar	.64 similar
5+	1.08 similar	3.56 similar	4.70 S 7>>S14	2.39 similar	1.46 similar

Pike Population Size

To obtain an estimate of the pike population size the Petersen method was used (Ricker, 1958). This estimate was made using certain modifications such as Bailey's which is represented as

$$N = \frac{M(C+1)}{R+1}$$

where:

N = estimated population size

M = number of fish marked

C = catch or sample taken for census

R = the number of recaptured marks in the sample

From the 99 returns (14.9 per cent) a number of observations were noted. The tagged pike were adversely affected in terms of growth. Growth was especially retarded the year in which the fish received the dart. Generally larger fish were affected less and thus continued a normal pattern of growth. Koshinsky (1972) at Lac La Ronge, Saskatchewan, noted similar effects on pike as a result of tagging with dart tags.

A number of assumptions must be made at this point so as to validate the actual population numbers:

1. Marked fish suffer the same mortality as the unmarked.
2. Marked fish do not lose their tags. No tag loss was observed and all fish sampled were examined for scars.
3. Marked fish return to their populations and become randomly mixed with the unmarked. Pike were released after tagging in essentially the same area as where they were originally caught.
4. All marked fish are recognized and reported on recovery. The author devoted two months at the peak of angler harvest

(May and June, 1973) to make anglers aware of the tagged fish, to examine all fish retained and to obtain a count on the numbers of fish being released.

5. Ten per cent of the pike being released are caught more than once. In the total estimation of population size one has to consider both the fish being retained as well as those being released as the sample catch (C). The correction factor of ten per cent is based on recapture of released fish as well as the tendency of anglers to overestimate the numbers of fish being released.

Table 19 shows the calculated population size from the 1972, 1973 and combined data. The number of pike 2+ and older is approximately 20,400. The validity of this number may be checked by the methods suggested by Robson and Reiger (1964). The values of MC appear closest in the 1973 data and the suggestion that MC must exceed four times the guessed value of N holds true. Davis (1964) worked with Petersen's population estimates and confidence intervals. The C/N value of 0.52 appears to fall into line with the graphs of Davis.

The population sizes in the different lake zones were calculated and are represented in Table 20. This table combines data from 1972 and 1973. Using the Petersen method the population size for each area has been determined and the combined estimates produce a total population figure higher than the one previously stated. The overestimate comes from two zones, S_7 and S_{14}, where few returns resulted in inflated N values. The table indicates a relatively high return (21 and 22%) from S_5 and S_{13}. These areas are the most heavily fished areas in the lake.

TABLE 19. Population size of pike at Seibert Lake

Time Period	M	R	Pike Retained	Pike Released	C	N (2+ and older)
1972	324	35	432	1401	1833	17,000
1973	616	53	522	1233	1755	20,398
Combined	663	99	954	2634	3588	23,824

TABLE. 20. Populations in different lake zones (Combined 1972 and 1973 data)

Zone	No. Marked	No. Recapt.	No. Pike Kept	No. Pike Released(x.9)	No. Pike Caught	Pike Population Size(N)	Fraction of Tags Returned
S_1	9	1	11	32	43	387	.11
S_2	35	4	17	39	56	490	.11
S_3	90	14	31	101	132	849	.16
S_4	7	1	4	10	14	98	.14
S_5	103	22	346	889	1235	5782	.21
S_6	3	0	1	6	7		0
S_7	36	2	23	114	137	*2466	.06
S_8	97	13	40	223	263	1962	.13
S_9	100	10	59	214	273	2730	.10
S_{10}	23	3	15	65	80	613	.13
S_{11}	0	0	0	1	1		0
S_{12}	8	1	1	15	16	128	.13
S_{13}	125	27	388	899	1277	5912	.22
S_{14}	26	1	18	50	68	*1768	.04
TOTAL	663	99	954	2634	3588	23185	.15

*Overestimation of N.

A major aim of the study is to determine the numbers of trophy sized pike. With a population of approximately 20,400 pike aged two years and older the question still remains how many pike seven years and older (designated trophy size) exist. Tiurin (1962) shows the natural mortality for pike to be about 28 per cent from each year class. Table 21 indicates Tiurin's scheme and how it assists to determine the numbers of 7+ and older pike in Selbert Lake.

The table shows 3,683 pike 7+ and older. Half of this number should be females with balanced sex ratio and since females are much larger in size they are the ones being selected for by the anglers; thus approximately 1841 pike are available when only natural mortality is considered.

Considering the angler exploitation we alter the numbers of available pike. Table 22 shows the exploitation rate at various ages as a result of tagging returns. The returns at various ages or exploitation rate was greatest in the 9+ age classes at 46.7%. The per cent return at age class eight was 33.3, at seven 20.8, at six 14.1 and at age class five 6.5 per cent. Age classes 10+ and older probably have an exploitation rate of fifty per cent but small numbers of these age classes are represented in Selbert Lake.

Looking back to table 21 the angler exploitation is taken into consideration with the natural mortality figures. Assuming that few pike are taken under the age of seven then we may use the angler exploitation rate to indicate the numbers of pike being taken. The figures now indicate that approximately 1550 pike seven years and older are present in the lake. To maintain this level approximately 660 pike may be taken at the rates indicated for each age class and from those 660 pike the sex ratio should be 1:1.

TABLE 21. Numbers of trophy pike in Seibert Lake

Age Class	Tiurin (1962) Natural Mortality	Seibert Lake 5.71 schemes from Tiurin	Angler Exploitation Rate	No. of Trophy Pike
2+	1080	5710		
3+	720	4111	.070	
4+	518	2958	.086	
5+	373	2130	.065	
6+	269	1536	.141	
7+	194	1108	.208	875
8+	140	799	.333	422
9+	101	577	.467	161
10+	73	417	*.50	58
11+	53	303	*.50	21
12+	38	217	*.50	8
13+	27	154	*.50	3
14+	19	108	*.50	1

* Approximately

TABLE 22. Return rate (exploitation rate) of pike of various age classes

Age Class	Number Tagged	Number Returned	Return Fraction
2+			
3+	43	3	.070
4+	152	13	.086
5+	138	9	.065
6+	128	18	.141
7+	120	25	.208
8+	48	16	.333
9+	15	7	.467
10+	1	0	*.50
11+	4	0	*.50
12+	0	0	*.50
13+	1	0	*.50
14+	0	0	*.50
TOTAL	663	99	.15

*. Approximately

Movements

Table 23 summarizes the movements of pike in which little or no movement was indicated by 78 per cent of the returns. Of those moving, minor movement (i.e.; from zone tagged to an adjacent zone) was noted in six of the 99 returns. Some trends or non-random movements were noted especially in the movement of individuals towards zone S_{13}. This zone is a prime spawning area thus an understandable movement towards this zone from poor spawning habitat zones. Some of the other major movements have been fish from poor habitat zones to zones of better habitat.

Most returns were at least one year or one spawning period after the tagging. Thus it appears that the majority of pike move in a very limited fashion even after spawning. Miller (1948) at Square Lake, Alberta noted stationary post spawning individuals but movements occured during spawning.

TABLE 23. Movements of pike in Seibert Lake. (Tagging returns)

Movement	Number of Pike	Comment
None	77	
Minor movement	6	One shore zone to an adjacent shore zone.
Major movement	9	Movement toward S_{13}; majority S_5 to S_{13}.
Major	7	Some trends related to habitat quality.
Total Movements	22	
Total Returns	99	

C. MICROENVIRONMENT EXAMINATION

To better understand the differences and simply to characterize and better describe the 14 selected lake zones, two areas of study were examined. These included the examination of bottom fauna at a consistent depth around the entire lake, and secondly, an intensive sampling of submergent vegetation at a consistent depth.

Other aspects relating to the microenvironment examination such as shoreline vegetation and bottom type will also be mentioned.

Bottom Fauna

A total of 72 samples, each consisting of two dredges (one-half square foot), was taken around the lake. Recorded at each sampling point were the following: bottom type, shoreline vegetation and bottom fauna analysis. All samples were taken at the 10 ft. (3.0 m) depth.

1. Bottom type

Table 24 indicates the fractions of bottom types found in each of the fourteen lake zones. A silt-like bottom was found in five locations: S 3, S 5, S 8, S 9 and S 13 and formed 17 percent of all bottom types at the 10 ft. (3.0 m) depth. Organic mud was found in three areas: S 5, S 8 and S 13 and formed only 7 percent of the bottom types sampled. The most general bottom type is the sand, gravel, rock which was found to be 100 percent of the following areas: S 1, S 2, S 4, S 6, S 7, S 10, S 11, S 12 and S 14. Thus from sampling, 75 percent of the lake bottom at the 10 ft. (3.0 m) depth is of the sand-gravel type.

Of note is the presence of very limited areas of silt and organic mud in S 7 and in S 14.

Generally the amount of silt or organic mud along the shoreline

TABLE 24. Bottom types in the selected lake zones at the 10 ft. depth

Sample	n	Bottom Type (percent)					
		Silt	Organic Mud	Sand	Sand-Gravel	Gravel-Rock	Rock
S 1	3				33	33	33
S 2	3			100			
S 3	5	80		20			
S 4	5			80	20		
S 5	9	10	25	40	25		
S 6	4			50	50		
S 7	6			30	70		
S 8	8	10	10	40	40		
S 9	9	45			45	10	
S10	6			30	70		
S11	3					100	
S12	3			70	30		
S13	4	50	50				
S14	3				30	70	
Percent		17	7	32	33	10	1

in the littoral zone is very limited and most of the bottom type is of a sand-gravel nature. The very spotty nature of the mud type bottom is indicated on the shoreline vegetation map, (Figure 36).

2. Shoreline Vegetation (Emergent and Floating)

Figure 36 shows the emergent and floating vegetation around the shoreline of Seibert Lake. Two major vegetative forms indicated on this figure are the bulrush, *Scirpus*, (Photograph 11) and the yellow pond lily, *Nuphar*, (Photograph 12).

Table 25 shows the abundance of shoreline vegetation found in each of the fourteen lake zones. Fifteen percent of the lake shore has no emergent or floating vegetation and is basically a sand or rock shoreline (Photograph 13). At least 78 percent of the shoreline has emergent *Scirpus* growing. In a very limited distribution (isolated) is *Nuphar* which was present in 19 percent of the samples. *Nuphar* and *Scirpus* were occasionally found growing together. Figure 36 shows the pockets of *Nuphar* to exist in S 3, S 5, S 7, S 8, S 9, S 13 and S 14. The largest patches occur in the two bay areas S 5 and S 13 but secondary patches were observed in S 8 and S 9. Very limited patches were noted in S 3, S 7 and S 14.

3. Bottom Fauna

Table 26 indicates the weights, volumes displaced and numbers of different types of bottom fauna found in the different lake zones. Of note are areas S 5 and S 6 which have large numbers and large masses of bottom fauna. The mass of bottom fauna in S 11 and S 12 was very small; S 12 and S 14 had the least number of organisms.

Figure 37 compares the abundance of bottom fauna found in the fourteen lake zones. The most productive area appears to be S 5 while the least productive area is S 11.

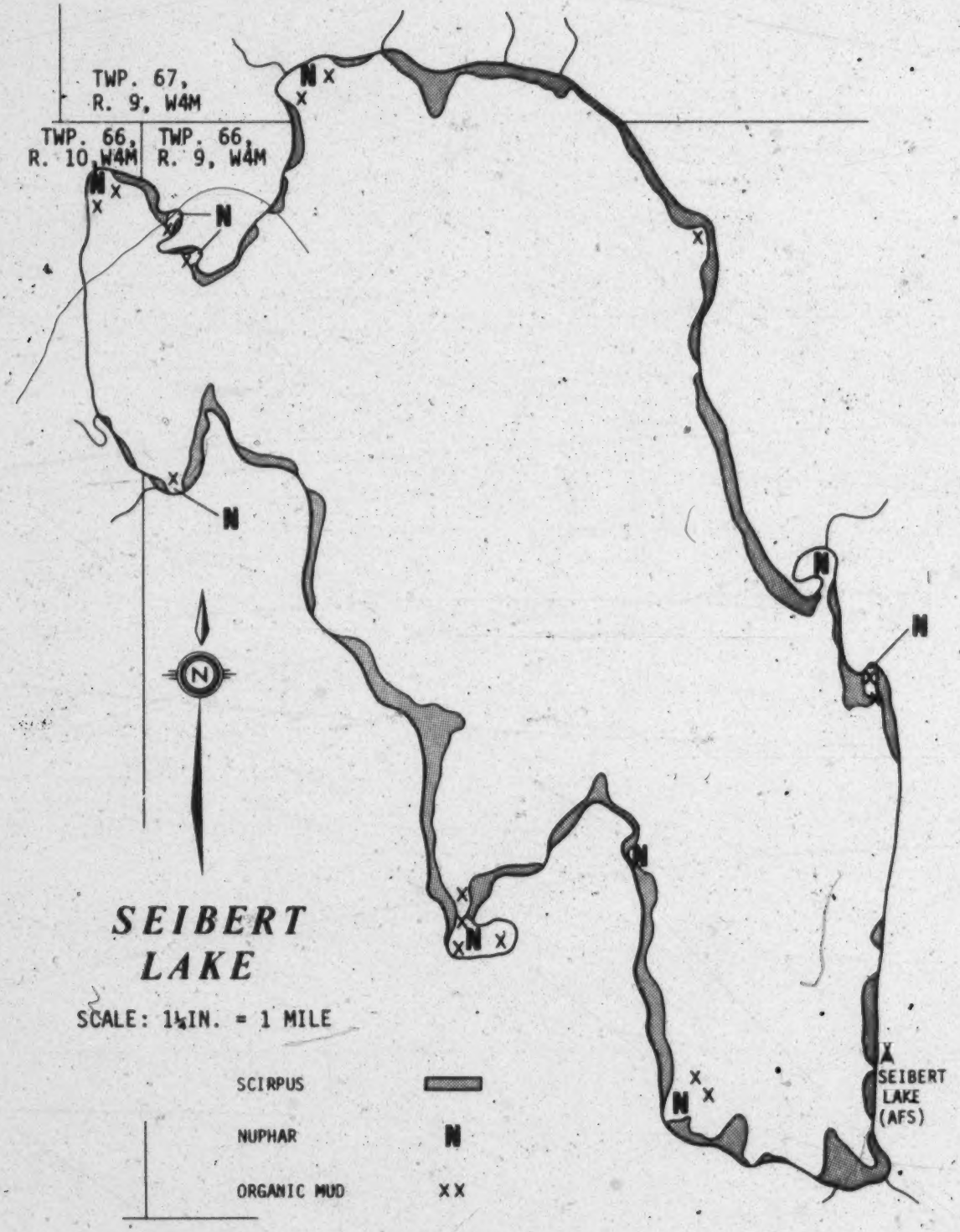


FIGURE 36. EMERGENT AND FLOATING VEGETATION TYPES

Photograph 11. The very common emergent vegetation is *Scirpus*, the water bulrush.

Photograph 12. The common floating vegetation is *Nuphar*, the yellow pond lily.

TABLE 25. Shoreline vegetation of the 14 lake zones

Sample Area	Shoreline Vegetation (percent)		
	Scirpus	Nuphar	Sand or Rock
S 1			100
S 2	100		
S 3	65	30	35
S 4	100		
S 5	100	30	
S 6	70		30
S 7	60	20	40
S 8	60	20	20
S 9	100	10	
S10	100		
S11	100		
S12	100		
S13	30	100	
S14	100	50	
Percent	78	19	15

Photograph 13. Fifteen per cent of the shoreline is barren of any emergent or floating vegetation. This photograph also represents typical walleye feeding grounds in late evening and night.

TABLE 26. Bottom fauna in lake zones at the 10 ft. depth (all data per m^2)

Organisms $\bar{x}$ numbers per m^2	Lake Zones S 1	S 2	S 3	S 4	S 5	S 6	S 7
n	3	4	5	5	9	4	6
Amphipoda	752.5	376.3	808.4	455.8	3463.7	2107.0	834.2
Diptera	21.5	28.0	352.6	86.0	855.7	215.2	83.9
Ephemeroptera	372.0	580.5	8.6	151.0	94.6	318.2	126.9
Trichoptera		6.5	17.2	12.9	25.8	10.8	19.4
Odonata	6.5	6.5	8.6	8.6	6.5	6.5	
Hemiptera				8.6	2.2		
Hirudinea	21.5	17.2	30.1	25.8	65.0	43.0	32.3
Oligochaeta	15.1	17.2	8.6		21.5	43.0	28.0
Mollusca	64.5	53.8	94.6	68.8	154.8	86.0	25.8
Total number per m^2	1254.6	1085.8	1328.7	817.0	4699.9	2820.8	1146.0
Total wet weight per m^2 (grams)	14.6	14.4	12.5	12.3	27.3	23.0	13.1
Total displaced volume per m^2 (ml)	13.3	13.5	11.4	11.6	25.8	21.1	12.3
Number of different species per sample	4.7	5.0	7.4	6.2	6.9	6.3	5.9

TABLE 26. Bottom fauna in lake zones at the 10 ft depth (all data per m^2) (cont'd)

Organisms	Lake Zones							
$\bar{x}$ numbers per m^2	S 8	S 9	S10	S11	S12	S13	S14	$\bar{x}$
n	8	9	6	3	3	4	3	5.1
Amphipoda	954.6	589.1	606.3	150.5	144.1	221.5	144.1	1021.3
Diptera	81.7	122.6	92.5	1877.0	150.5	301.0	49.5	294.6
Ephemeroptera	148.4	176.3	329.0	15.1	258.0		322.5	189.2
Trichoptera	10.8	8.6	4.3		6.5	17.2		11.6
Odonata	2.2	8.6	8.6			6.5		4.5
Hemiptera								0.8
Hirudinea	38.7	38.7	25.8		6.5	65.0	21.5	34.4
Oligochaeta	17.2	12.9	15.1	15.1	15.1		15.1	15.1
Mollusca	38.7	49.5	21.5		6.5	19.4	15.1	66.7
Total number per m^2	1294.3	1004.1	1096.5	2070.5	587.0	802.0	565.5	1612.5
Total wet weight per m^2 (grams)	13.8	16.6	15.1	5.8	6.7	11.8	13.8	15.5
Total displaced volume per m^2 (m^1)	12.7	15.5	14.0	5.4	6.2	10.5	13.5	13.3
Number of different species per sample	5.5	6.4	5.2	4.0	4.7	8.0	4.0	5.9

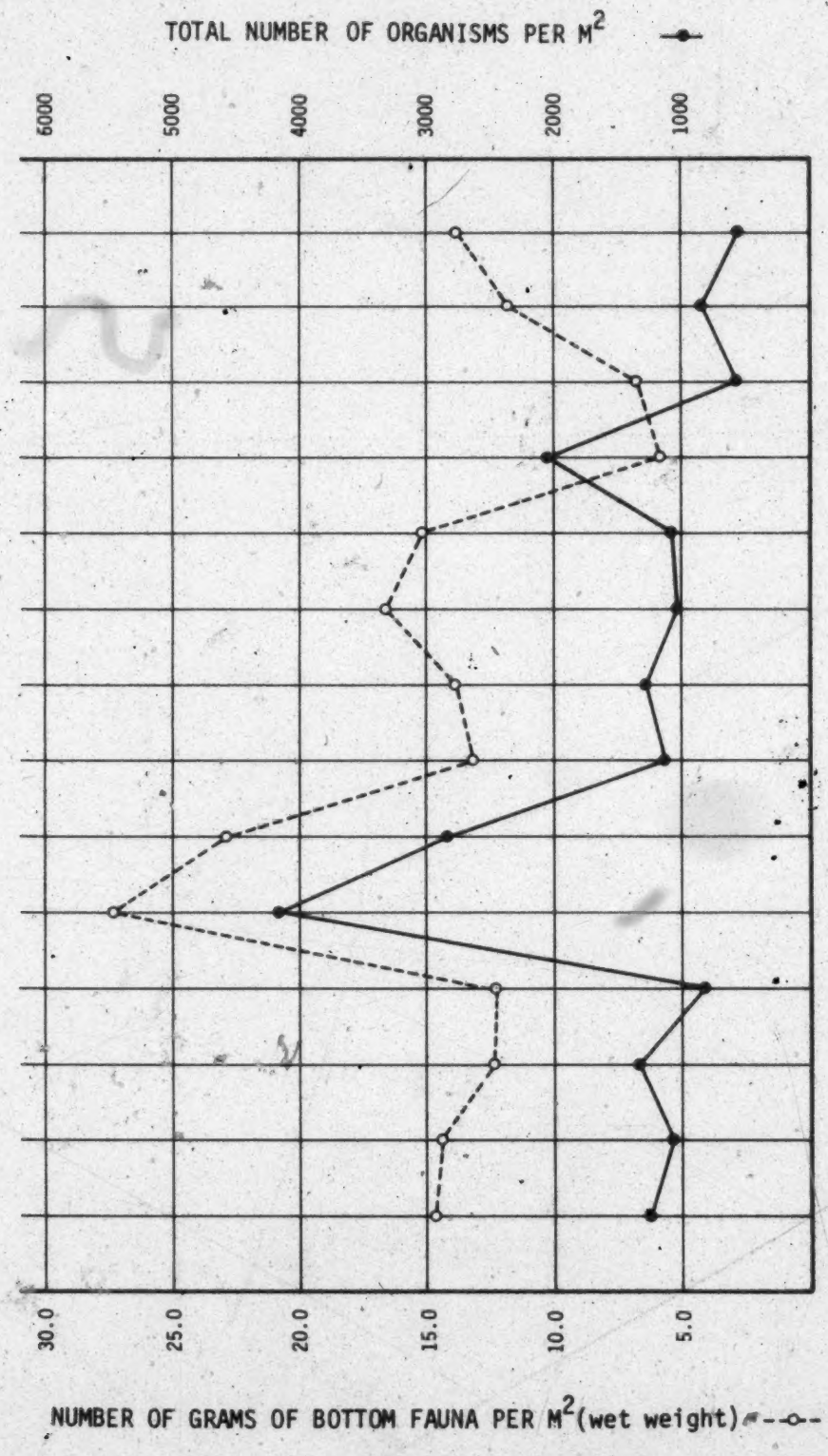


FIGURE 37 BOTTOM FAUNA AT THE TEN FOOT DEPTH IN DIFFERENT AREAS OF THE LAKE

Table 26 also shows the differences in the abundance of various organisms in different lake zones. For example, hirudineans are most abundant in S 5 and S 13. In a later section a comparison of bottom fauna and fish diets shall be discussed and the abundance of leeches may be of importance.

Table 26 has a column with the mean number of different types of organisms in each area. The most diverse areas were S 13, S 3 and S 5, while the least diverse were S 11 and S 14.

Figure 38 shows the percentage of the total numbers of different types of bottom fauna. Amphipods (63.3%) are the most abundant; dipterans (mainly *Tendipes*) are second with 18.3% of the total number; ephemeropterans (11.7%) and molluscs (4.1%) are third and fourth. The mayflies were mainly of the genus *Ephemera*. The molluscs were mainly of the genus *Pisidium* but a number of gastropod types were also found.

A list of the bottom fauna found at the 10 foot (3.0 m) depth is indicated in Appendix XV.

Vegetation

Submergent vegetation was sampled in late July (1972) over a period of two weeks. All samples were taken at an 8 to 10 foot (2.4-3.0 m) depth and a total of 364 samples were taken.

A list of the plants found in Seibert Lake is shown in Table 27. This table indicates the abundance of those sampled as well as those forms not sampled but observed.

Table 28 shows the vegetation sampling results for all plants in the 14 lake zones.

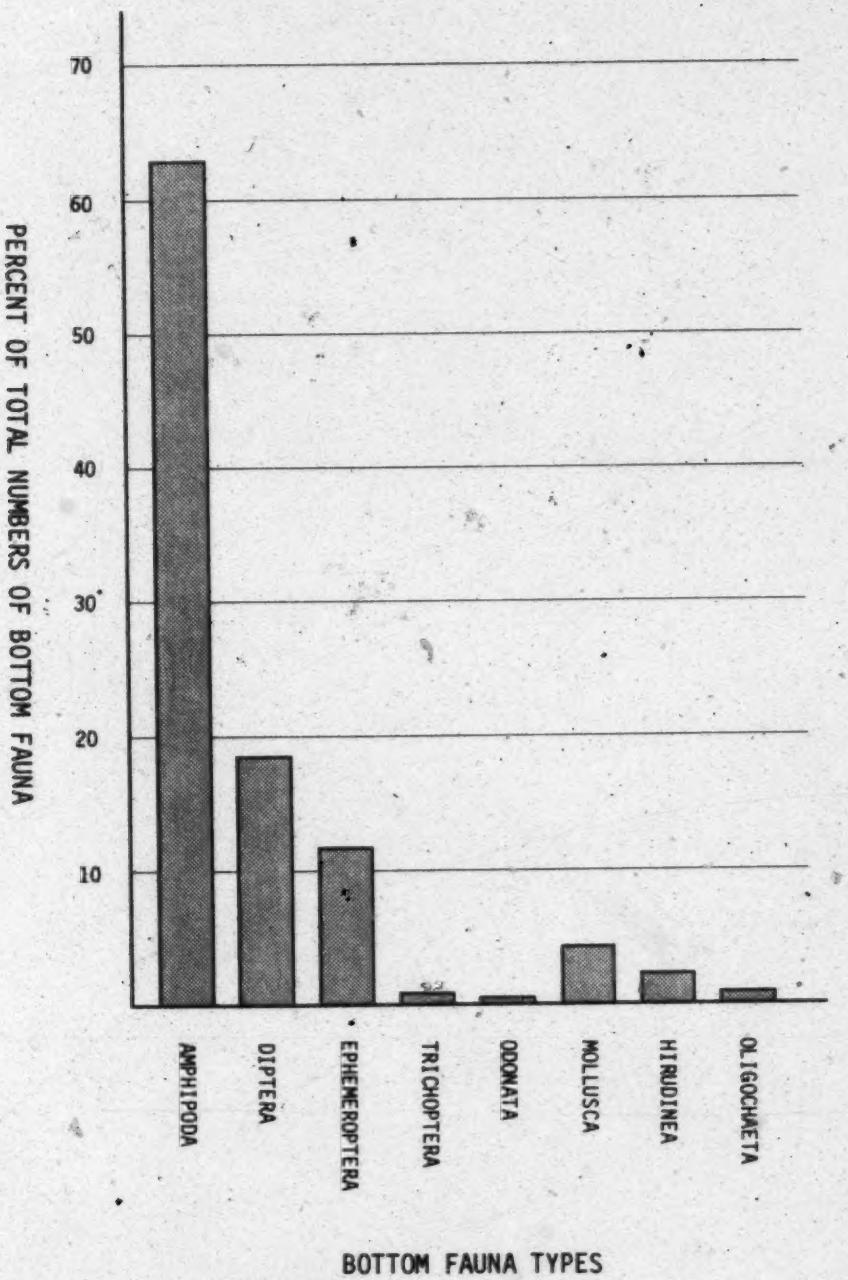


FIGURE 38. BOTTOM FAUNA AT THE TEN FOOT DEPTH

TABLE 27. Vegetation types from Seibert Lake

Submerged Sampled Plants Scientific Name	Common Name	Percent Occurrence	Percent of all Plants
Chara sp.	Chara, a green algae	39.3	32.2
Potamogeton praelongus Wulf.	White-stem pondweed	15.7	12.8
P. natans L.	Floating pondweed	17.3	14.2
P. vaginatus Turez	Slender pondweed	20.1	16.4
P. zosteriformis Fern.	Flat-stemmed pondweed	3.3	2.7
P. gramineus L.	Variable pondweed	1.7	1.4
Myriophyllum exalbescens Fern.	Water milfoil	10.7	8.8
Utricularia sp.	Bladder wort	3.8	3.2
Ceratophyllum demersum L.	Coontail	3.3	2.7
Drepanocladus sp.	Moss	2.5	2.0
Hippuris sp.	Marestail	2.8	2.3
Nuphar variegatum Engelm.	Yellow pond lily	1.7	1.4
Others			
Potamogeton richardsonii Rydb.	Clasping-leaf pondweed		
Emergent or Floating			
Scirpus validus Vahl.	Water bulrush		
Nuphar variegatum Engelm.	Yellow pond lily		
Polygonum sp.			
Typha latifolia L.	Cattail		
Carex sp.	Sedges		
Lemna trisulea L.	Duckweed		

TABLE 28. Vegetation sampling results

Lake Zone	n	Nothing	Chara	Potamogeton praelongus	Potamogeton natans	Potamogeton vaginatus	Potamogeton zosteriformis	Potamogeton gramineus	Myriophyllum	Utricularia	Hippuris	Ceratophyllum	Drepanocladus	Nuphar	Number of plant types
S 1	20	13	7					2							2
S 2	24	4	20		8	1		2		1					5
S 3	20	3	7	4		11			5	1				1	6
S 4	20	5	5	2	6	2			7	2					6
S 5	36	6	12	5	13	18	2	1	9	6		4	8	1	11
S 6	24	1	23		3	1									3
S 7	36	2	15	7	5	10	4		5		5			2	8
S 8	36	7	10	9	9	6			9	1	2			1	8
S 9	40	7	20	16	9	11	1	1							6
S10	32	10	17	6	5	9			3						5
S11	20	18	2												1
S12	16	7	4	2	5					1	3				5
S13	20	7	0	2		3	5		1	1		8		1	7
S14	20	15	1	4		1				1					4
Total	364	105	143	57	63	73	12	6	39	14	10	12	9	6	

Table 29 compares the bareness of the lake in relation to the various lake zones. Figure 39 compares the fourteen locations in terms of percent nothing, percent *Chara* and percent other vegatation. The figure shows that some areas have generally a very barren nature with very little vegetation. *Chara* is a green algae that basically provides no habitat for pike but does provide habitat for invertebrates. It is a very short vegetative form growing very close to the substrate, thus it is grouped with the "nothing" points as a determinate of pike habitat quality.

The percent vegetation cover (other than *Chara*) is alone not necessarily an indication of prime habitat. The diversity value associated with each zone is portrayed in Figures 40 and 41. Figure 40 shows the diversity as:

$$\frac{\text{Total number of plant species excluding } \textit{Chara}}{\text{Total number of sampling points}}$$

The greatest diversity is noted in S 3, S 4, S 5, S 7, S 8, S 9 and S 13 and is partially indicative of pike habitat quality.

Figure 41 also shows the diversity but includes *Chara* as one of the plant species. With *Chara* the overall diversity of the habitat increases in all areas to a point where an average of one plant per sample point is reached. Three areas even with *Chara* are quite barren; these are S 1, S 11 and S 14.

Figure 42 shows the percent occurrence vegetation at the 10 foot (3.0 m) depth. *Chara* is most abundant (39.3%) while three pondweeds *Potamogeton vaginatus* (20.1%), *P. natans* (17.3%) and *P. praelongus* (15.7%) are next in abundance.

TABLE 29. Per cent cover of submergent vegetation at the ten foot depth in the 14 lake zones.

Sample	Percent Nothing	Percent Chara	Percent Other Vegetation	1. Average No. of Plants per Vegetative Site	2. Habitat Diversity	Bareness Percent Nothing and Chara
S 1	65	25	10	1.0	0.10	90
S 2	17	41	41	1.2	0.50	58
S 3	13	5	80	1.4	1.10	18
S 4	25	20	55	1.7	0.95	45
S 5	17	8	75	2.5	1.89	25
S 6	4	79	17	1.0	0.17	83
S 7	6	31	63	1.7	1.06	37
S 8	19	19	62	1.7	1.02	38
S 9	18	12	70	1.4	0.95	30
S10	31	14	55	1.4	0.72	45
S11	90	10	0	0	0	100
S12	44	0	56	1.2	0.69	44
S13	35	0	65	1.6	1.05	35
S14	75	5	20	1.5	0.30	80
Total	28.8	20.1	51.1			48.9

1. Average no. of plants per vegetative site = $\frac{\text{Total no. of plants in a lake zone}}{\text{No. of samples with plants}}$

2. Habitat Diversity = $\frac{\text{Total no. of plant species excluding Chara}}{\text{Total no. of sampling points in particular zone}}$

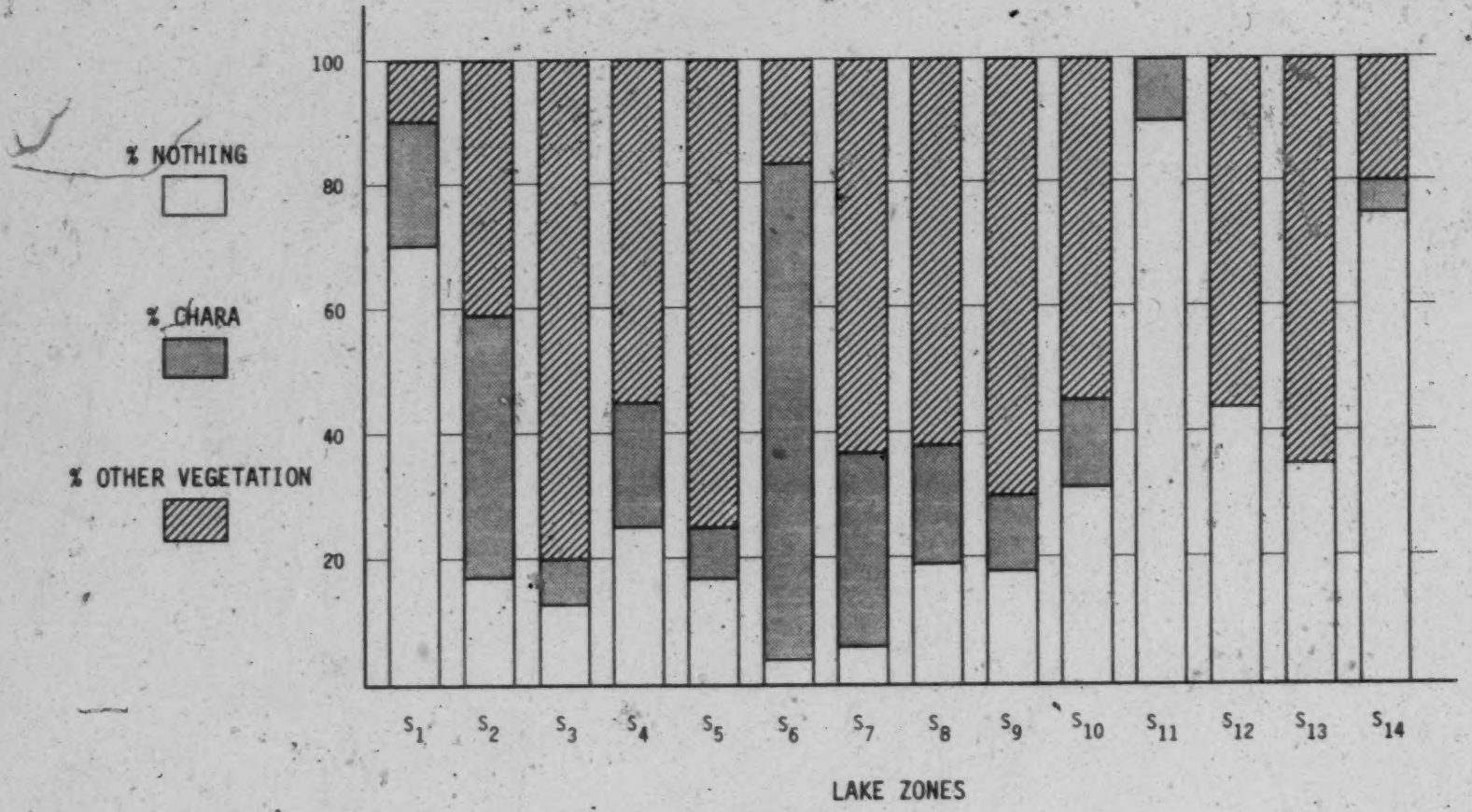


FIGURE 39. VEGETATION: PERCENT VEGETATION IN DIFFERENT LAKE ZONES

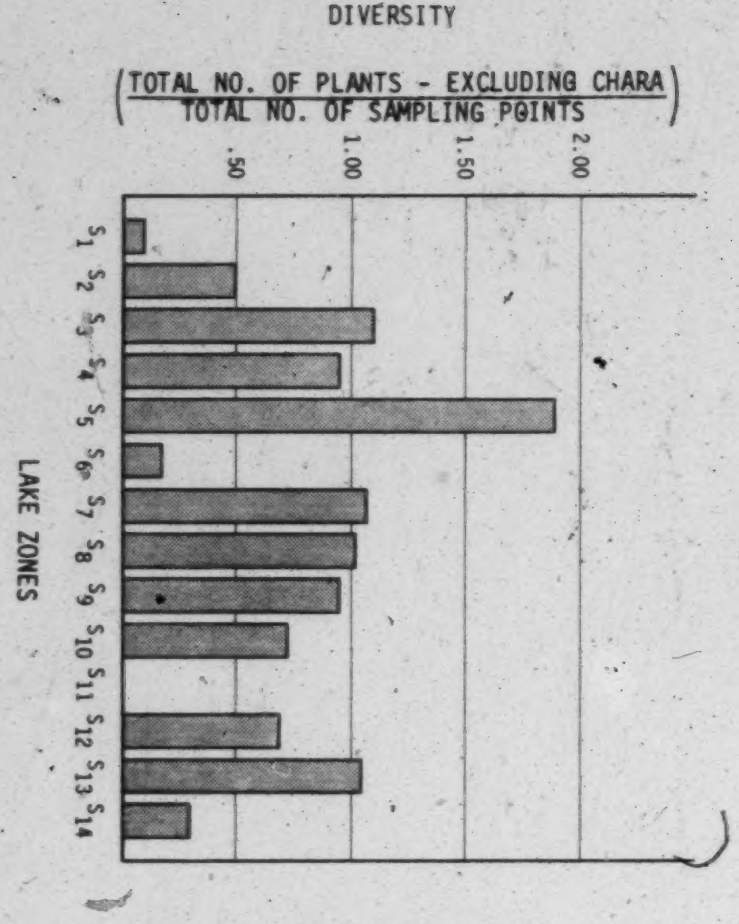

DIVERSITY
(TOTAL NO. OF PLANTS - EXCLUDING CHARA / TOTAL NO. OF SAMPLING POINTS)
.50
1.00
1.50
2.00
LAKE ZONES
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14

FIGURE 40.

VEGETATION DIVERSITY: HABITAT QUALITY

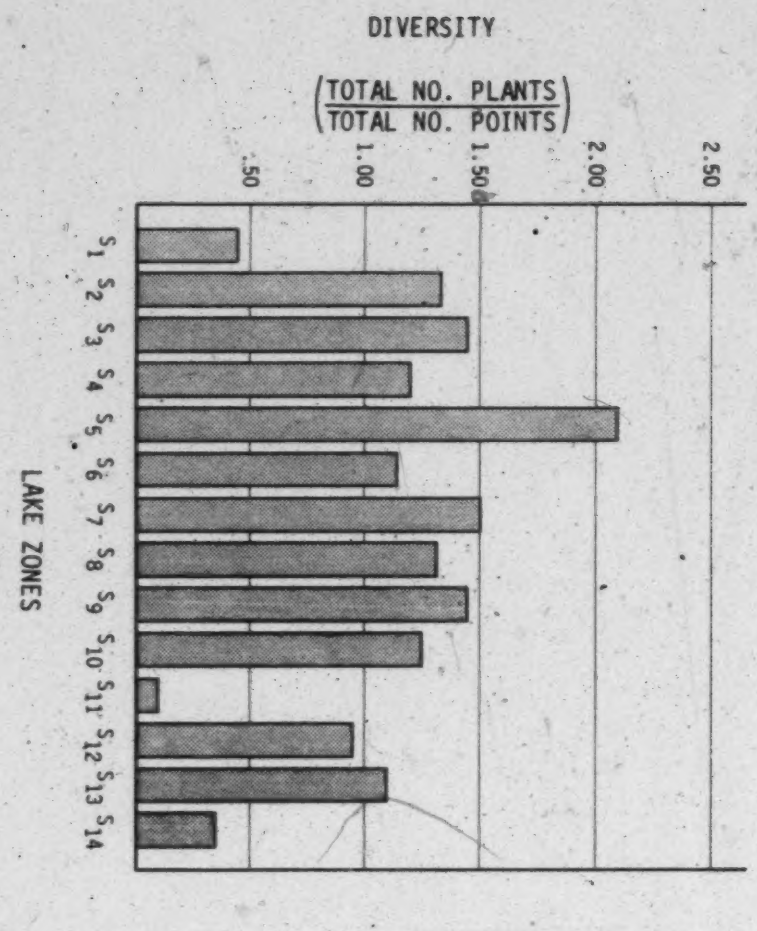


FIGURE 41.

VEGETATION DIVERISTY: HABITAT QUALITY

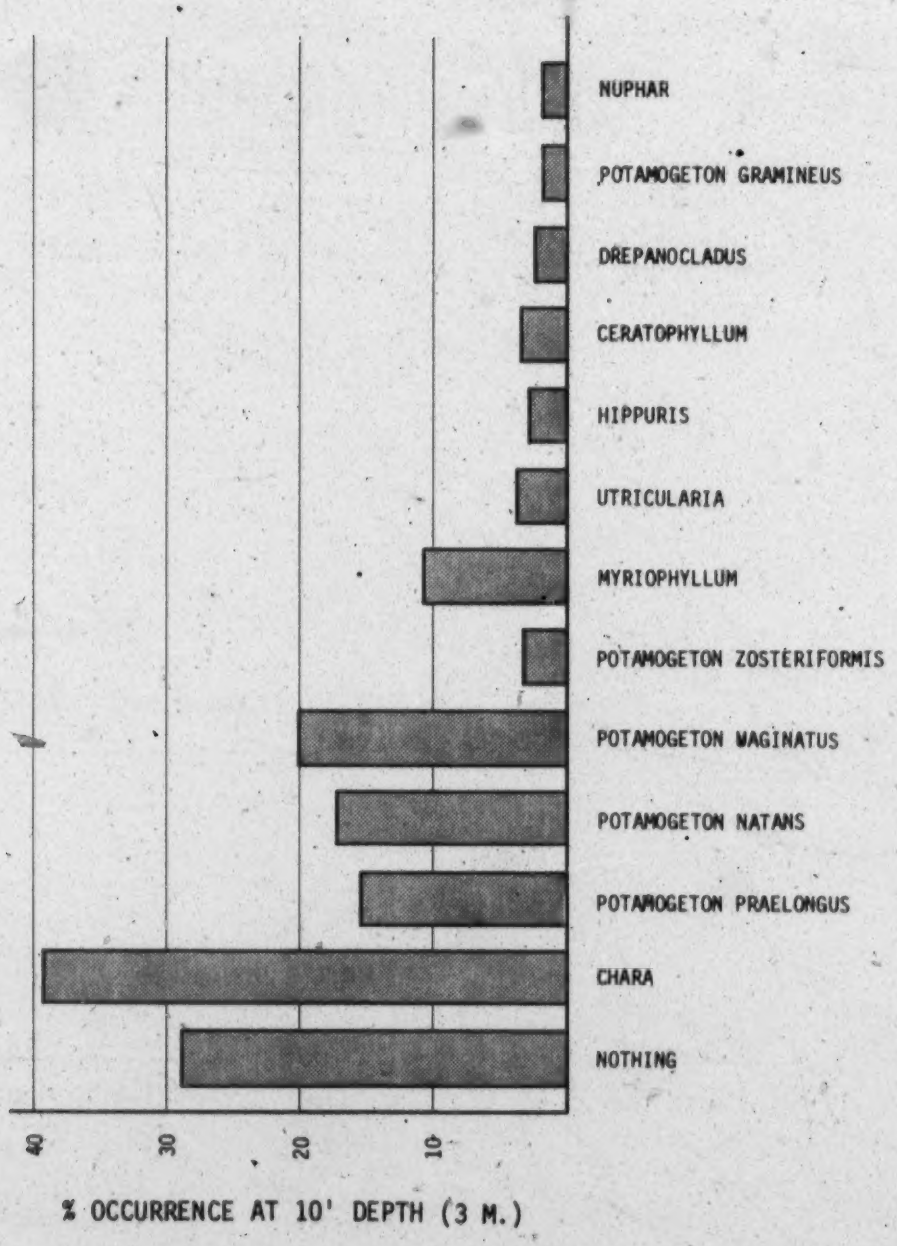


FIGURE 42. LAKE VEGETATION: PERCENT OF DIFFERENT TYPES OF VEGETATION

The various plants have different structures thus different plants form more adequate habitat for different types of living organisms. Based on this idea, the author has subjectively made a scale from one to five to indicate a plant's potential in the formation of good pike habitat: Also a consideration of the size of pike is included in this number; that is, the plant which forms a better habitat for large pike will be higher on the scale than a plant suited only for small pike.

Looking at each of the plant forms some general statements may be made about each.

1. *Chara*, green algae #1 is abundant in sand, gravel and rock substrates. Its growth form is very close to the substrate and thus provides poor pike habitat but does provide quite good habitat for bottom fauna. Abundant numbers of mayflies appear to be associated with *Chara*. Lake zone S 6 has an abundance of *Chara* in a very thick mat.

2. *Potamogeton praelongus*, white-stem pondweed #5, is found in waters as deep as 16 ft. (4.8 m). It is found in silty or organic-like substrates. The tall leafy growth form allows for quite good cover and shade for very large fish.

3. *Potamogeton natans*, floating pondweed #4, is found in waters as deep as 12 ft. (3.6 m). It was rarely seen to have leaves actually floating. The leaves which are quite large form a canopy which sometimes reaches the surface but most often are from one to three feet (30.5-91.4 cm) from the surface. This plant provides fairly good cover and shade for fairly large fish. It may grow on quite sandy substrates.

4. *Potamogeton vaginatus*, slender pondweed #3, grows in water as deep as 10 ft. (3.0 m). It is grassy in appearance having narrow leaves and stems; it does not grow extremely tall, but when in a silty substrate, forms are much more robust as when growing in sandy substrate. Their structure allows habitat for relatively small fish.

5. *Potamogeton zosteriformis*, flat-stemmed pondweed #3, is found in 8 to 10 ft. (2.4-3.0 m) of water. It appears to be most abundant in S 5 and S 13 bays, growing in a silty-organic substrate. They provide some habitat for relatively small fish.

6. *Myriophyllum* sp., water milfoil #2, is found in fairly shallow water with often a silty-organic substrate. Their growth form is quite short with no large leaves thus their importance in pike habitat is limited to smaller fish. It has some importance as a vegetative form used by pike during spawning.

7. *Utricularia* sp., bladderwort #2, growth form similar to *Myriophyllum*.

8. *Ceratophyllum* sp., coontail #2, growth form quite similar to *Myriophyllum*. This plant form provides habitat for smaller fish. It is isolated to the S 5 and S 13 bays and it is a vegetative type used by pike in spawning.

9. *Drepanoeladus* sp., moss #1, is a form found only in the S 5 bay area. It provides excellent habitat for many invertebrates, in particular amphipods. It grows in a mat thus forming a spongy bottom. It grows in highly organic bottom types characteristic of eutrophic lakes.

10. *Hippuris* sp., marestail #2, is very isolated. Its growth form is one of short leaves and short height, up to one foot in height. Found in areas with a sandy substrate. Possibly provides some habitat for small fish.

11. *Potamogeton gramineus*, variable pondweed #2, is much like a short grass. Not common and does not provide habitat for very large fish.

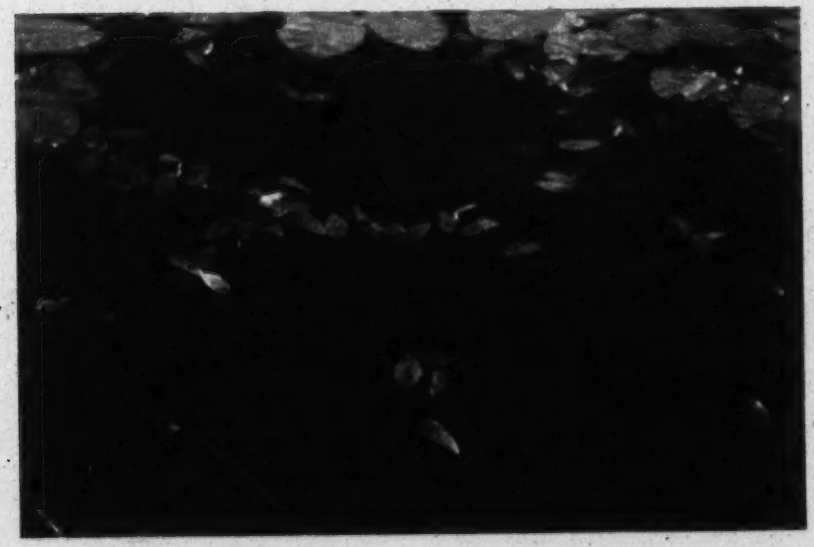
12. *Nuphar variegatum*, yellow pond lily #5, is isolated to certain areas of the lake. It grows in water as deep as 10-12 ft. (3.0-3.6 m) and in a silt-organic substrate. It provides excellent cover and shade for large fish. *Nuphar* grows with a wide variety of other plants thus providing a greater diversity of habitat type (photographs 14 and 15).

Other plants were present but in very small numbers and usually inconspicuous. *Potamogeton richardsonii*, clasping-leaf pondweed, was not common but could provide some habitat for some fairly large fish.

Taking into consideration the individual plant quality, Figure 43 indicates the prime lake zones for pike. S 5 and S 9 seem to be the superior habitats but certain factors such as floating aquatics and overall diversity have not been considered in this number of habitat quality.

Another important aspect of habitat is the number of different plants in an area. Table 28 indicates the number of plant species in each lake zone. Areas with a wide variety of plants include S 5, S 7, S 8 and S 13, while areas with few plant species include S 1, S 6, S 11 and S 14.

Photograph 14. *Nuphar variegatum* - yellow pond lily.



Photograph 15. Yellow pond lily with other plant types thus forming a more diversified habitat.

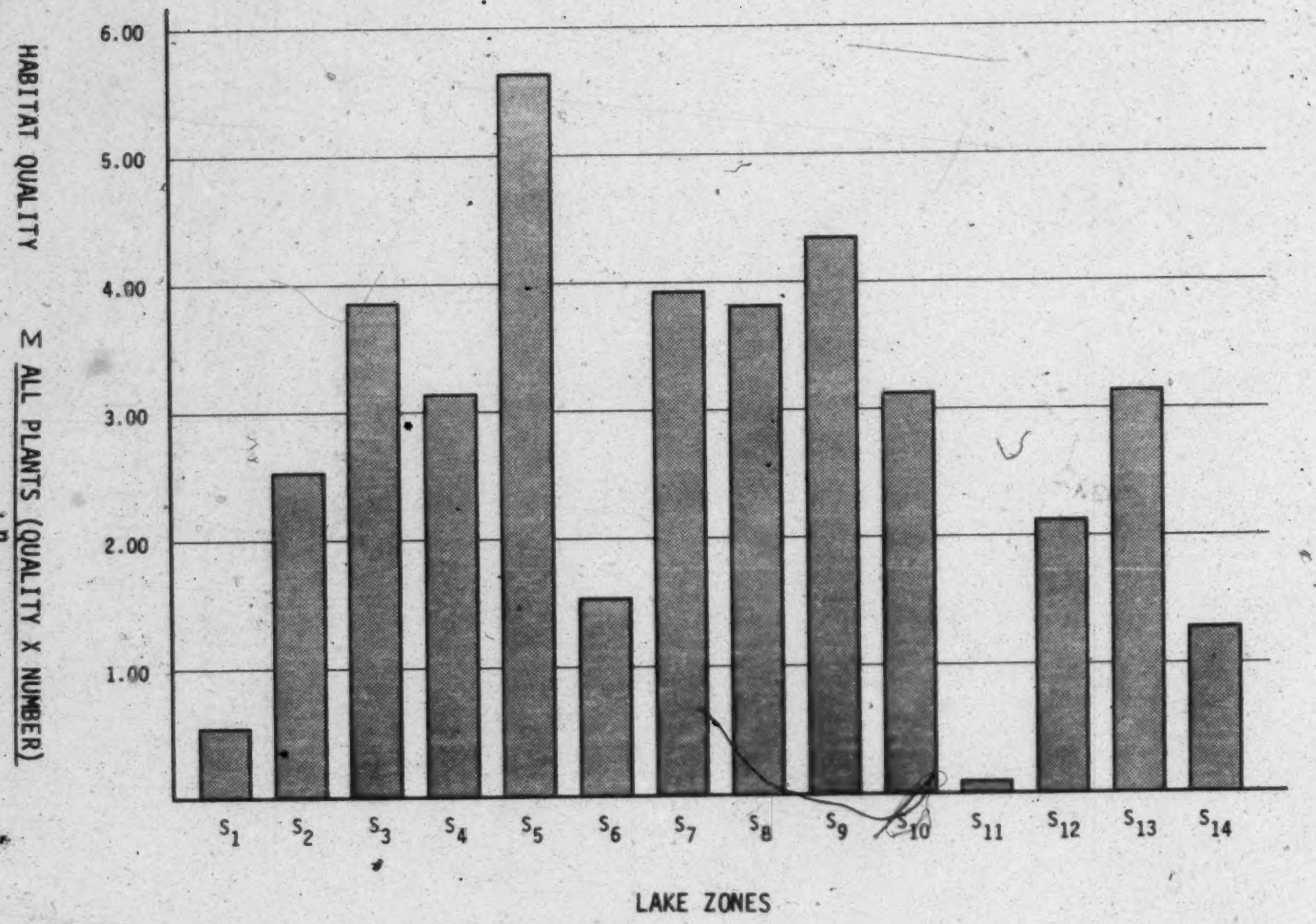


FIGURE 43. PIKE HABITAT QUALITY

D. PUBLIC UTILIZATION

Public utilization of the trophy lake fishery resource was studied in a number of ways. First, a questionnaire (Appendix II (A) and (B) was sent out to all trophy lake licencees of the 1971-72 fiscal year. Its purpose was to make an initial evaluation of which trophy lakes were being used to the greatest extent. Secondly, angler interviews in the form of a creel census were carried out to evaluate angler success and general utilization of the Seibert Lake fishery resource. Thirdly, a comparison and evaluation of the changes in the utilization of this resource since its origination in 1970 was carried out.

(a) Questionnaire

At the end of the 1971-72 fiscal year the questionnaire was sent to all purchasers of trophy lake licences. Table 30 indicates the results of the questionnaire and the following points are the highlights:

1. The majority of licencees visit Seibert Lake (51.1%) while no questionnaires were returned from people visiting Andrew or Gardiner Lakes.
2. The average number of times an angler visits Seibert Lake is 2.0 while the average number of times other trophy lakes are visited is 2.5.
3. The majority of visits to Seibert Lake are in the spring period, May-June (54.6%). In the four months from May to August over 70 percent of the visits are made. Many comments from anglers indicate poor angling success during the winter. Most anglers visiting the lake in the winter (17%) are interested mainly in the walleye.

The questionnaire served several purposes. First, it indicated the position (usage) of Seibert Lake among the other six trophy

TABLE 30 . Questionnaire results

Number of questionnaires sent		404	
Number of People returning questionnaires		227	(56.2%)
Number of people visiting the trophy lakes:			
	God's	35	(13.4%)
	May	28	(10.6%)
	Namur	26	(9.9%)
	Seibert	134	(51.1%)
	Winefred	30	(11.4%)
	Unable to reach lake	9	(3.4%)
Number of times each lake was visited:			
	God's	54	(10.0%)
	May	50	(9.2%)
	Namur	37	(6.8%)
	Seibert	273	(50.3%)
	Winefred	129	(23.8%)
Number of times Seibert Lake was visited in:			
	Winter (Nov.-April)	45	(17.2%)
	Spring (May-June)	143	(54.6%)
	Summer (July-August)	43	(16.4%)
	Fall (Sept.-October)	31	(11.8%)
Average number of times an angler uses a trophy lake in one season			2.4
Average number of times an angler uses Seibert Lake in one season			2.0

lakes and secondly, it indicated the time of year that most anglers visit the lake as well as indicating when the majority of trophy pike are being removed from the lake. The questionnaire also allowed the trophy lake licencees to make comments about the concept, its structure and its administration, thus giving the Alberta Fish and Wildlife Division a certain amount of constructive feedback.

(b) Creel Census

A creel census was carried out in the spring-summers of 1971, 1972 and 1973. The purpose of this census was to attain information about:

(a) numbers of fish caught and released

(b) location in which fish were caught and released

(c) weights, lengths and ages of fish

(d) angler's place of residence

(e) the amount of effort in man hours

(f) tagged fish

The objectives of the 1973 creel census were to document the tagged fish being caught and to obtain the total numbers of pike being caught either retained or released.

The 1971 and 1972 creel census results are listed in Tables 31 and 32. Some of the aspects of the fishery which are of importance are indicated in a comparison of angler success in 1971 and 1972 (Table 33). A very important factor to consider when comparing visitation from year to year is the weather and the resulting road conditions. The June of 1971 was an extremely wet and cold month hence the road improved very little until the fall. In 1972 the road was quite good and thus even cars were successfully making it to the lake.

TABLE 31 . 1971 Creel Census

Date (month)	No. of Days Censused	No. of Parties	No. of Anglers	Man Hrs. Angling	Fish Species	Fish Retained	Fish Released
May	7	33	97	873.5	Pike	104	510
					Walleye	323	115
					Whitefish	2	
					Burbot	1	
						430	625
June	6	15	38	186	Pike	23	97
					Walleye	162	21
					Whitefish	1	
						186	118
July	17	12	37	226	Pike	35	138
					Walleye	242	23
					Perch	1	
						278	161
August	16	13	48	373	Pike	18	322
					Walleye	200	260
						218	582
1971	46	83	220	1640.5	Pike	180	1067
					Walleye	927	419
					Whitefish	3	
					Perch	1	
					Burbot	1	
						1112	1486

TABLE 32. 1972 Creel Census

Date (month)	No. of Days Censused	No. of Parties	No. of Anglers	Man Hrs. Angling	Fish Species	Fish Retained	Fish Released
May	23	79	222	1992.25	Pike	244	915
					Walleye	689	303
						933	1218
June	16	34	97	867.5	Pike	99	463
					Walleye	432	243
						531	686
July	16	27	81	774.0	Pike	56	382
					Walleye	412	97
						468	479
August	20	28	69	303.0	Pike	30	163
					Walleye	131	50
						161	213
1972	75	168	469	3937	Pike	429	1923
					Walleye	1664	693
						2093	2616

TABLE 33 . Angler success

		1971	1972
Pike caught per man hour of angling		0.76	0.60
Walleye caught per man hour of angling		0.82	0.60
Fish caught per man hour of angling		1.58	1.20
Pike kept per man hour of angling		0.11	0.11
Walleye kept per man hour of angling		0.56	0.42
Fish kept per man hour of angling		0.67	0.53
Number of fish taken per angler trip			
	Pike	0.82	0.91
	Walleye	4.20	3.55
	Total	5.02	4.46

Some of the notable results are:

(a) More than 50 per cent of the angling parties visiting Seibert Lake came from Edmonton.

(b) In both years 1971 and 1972 walleye amounted to 80 per cent or more of the total fish taken out of the lake. But in comparing the total numbers caught, pike and walleye were almost equal in 1971.

(c) Each angler spent approximately 8 hours (7.5 hours in 1971; 8.4 hours in 1972) angling on each fishing trip. This implies that most trips are two days in duration, weekends.

(d) The number of fish caught (retained plus released) per man hours of angling was 1.58 in 1971 and 1.20 in 1972.

(e) The amount of time required to capture a trophy pike (greater than six pounds) is probably in excess of ten hours (.11 pike retained per man hour of angling). If one looks at the spring period the success is much greater and the amount of effort is much reduced.

c. Three Year Comparison of the Trophy Lake Concept

The trophy lake concept originated in the 1970-71 fiscal year. Table 34 indicates the number of trophy lake licences sold in the first three years of the concept. The percentage increase from the conception is 159.2 per cent i.e. from 282 in 1970 to 731 in 1972-73.

The places of residence of trophy lake licencees in 1970-71, 1971-72 and 1972-73 are listed in Table 35. Edmonton residents formed the greatest percentage of licencees; 45.7 per cent in 1970-71, 31.4 per cent in 1971-72 and 36.3 per cent in 1972-73. Local residents were the second most important purchasers of trophy lake licences. Some trends are noted in the area of residents from far away places. The number of visitors from the United States has been increasing in proportion to all other visitors.

TABLE 34. Three year comparison of trophy lake interest in terms of licences sold

Year	Number of Licences	Percent Increase from Previous Year	Percent Increase from First Year
1970-71	282		
1971-72	411	45.7	45.7
1972-73	764	83.5	170.9

TABLE 35 . Place of residence of trophy lake licences

Place of Residence	Percentage of Anglers 1970-71	1971-72	1972-73
Edmonton	45.7	31.4	36.3
Calgary	3.5	4.6	4.3
Red Deer	0	2.6	1.5
Local (Bonnyville, St. Paul, Cold Lake, Ft. McMurray, Lac La Biche)	22.0	31.4	25.4
Other Places in Alberta	25.2	22.6	21.9
Other Provinces	0	0.8	2.0
United States	3.5	6.7	7.8
Other Countries	0	0	0.8

DISCUSSION

The purpose of this study has been stated in three statements based mainly on the problem of how to manage Seibert Lake for the large northern pike. In other words, why do they grow as they do and how many of these large fish are there? The topics presented in the results section will be discussed in terms of a comparison with other works as well as interrelating all aspects of this study.

Limnological Aspects

The physical and chemical findings indicate that Seibert does not stratify in mid-summer; there is no thermocline and oxygen levels are uniform from top to bottom. The lake is well exposed to prevailing winds and with the maximum depth of only 36 feet (12.0m) the lake mixes thoroughly. Since a characteristic epilimnion and hypolimnion are absent in the summer, the distribution of fish is not limited by temperatures or oxygen levels.

Table 36 compares the mineral analyses of water from seven central Alberta lakes. Total dissolved solids (TDS) have been considered as being an important factor in lake productivity (Northcote and Larkin, 1956). Ryder (1965) went one step further using mean depth and TDS to indicate fish productivity. The higher the dissolved solids and the shallower the lake the greater the lake productivity. Seibert is quite a productive lake considering its mean depth of 19.9 feet (6.2m). The TDS in Seibert is high in comparison to other lakes indicated in the table. Seibert lake water has a high calcium carbonate count thus making it quite hard. Hayes and Anthony (1964) claim that hard waters produce good crops of fish and

TABLE 36. Mineral analyses of water in eight central Alberta lakes expressed in parts per million.
(Data other than Seibert Lake from McDonald, 1967 unpubl.)

Lake	Location	Total Dissolved Solids	Ignition Loss	Hardness	Alkalinity
Seibert	66-9-W4	336	178	194	220
Lac St. Anne	55-3-W5	180	88	115	130
Moose	60-6-W4	486	180	230	250
Muriel	59-5-W4	644	214	310	420
Pinehurst	65-10-W4	210	100	130	150
Pigeon	47-1-W5	294	162	160	160
Winefred	75-4-W4	184	70	105	110
Wolf	66-7-W4	336	142	170	215

more specifically Carlander (1955) found a strong positive correlation between fish standing crop and carbonate content of the water.

Plankton was sampled but it seemed of little relevance to the problem. Of note is that very little phytoplankton was present and no blooms appeared during the summers of 1971 and 1972. Personnal communication with Dale Allen (University of Alberta) indicated some correlation with non-blooming and the presence of the green algae, *Chara*. Lakes, like Seibert, containing *Chara* do not appear to bloom noticeably.

The bottom fauna showed marked differences in mass and volume between profundal and littoral regions. Approximately 40 per cent of the lake is of relatively high bottom fauna production. Table 37 compares the bottom fauna abundance in several Alberta lakes. Turner (1967, unpubl.) from Wabasca Lake, Alberta showed little difference in the amount of bottom fauna between littoral and profundal zones. Significant differences are noted at Seibert Lake. The variation in sampling in profundal regions is less than the variation in littoral regions which would indicate that littoral regions require greater sampling in order that valid values are obtained.

With such distinctions in the distribution of bottom fauna one could presume that fish feeding upon these organisms would be distributed accordingly.

Pinsent (1967) in comparing Beaver Lake and Lac La Biche found a greater diversity of bottom fauna in the littoral region. This is also the situation at Seibert and appears to have some importance in the distribution of fish in different seasons of the year.

TABLE 37. Abundance and volume of bottom fauna in seven Alberta lakes.

Lake	Mean No. of Organisms per Square Meter	Mean Volume (ml.) of Organisms per m^2
Seibert	1761.6 littoral	14.56 littoral
	1602.5 profundal	4.23 profundal
[1]Lac Ste. Anne	1211	15.9
[1]Moose	2720	60.8
[1]Muriel	731	5.9
[1]Wabamun	1026	12.7
[2]Wabasca	5636 littoral	42.3 littoral
	3427 profundal	39.2 profundal
[1]Winefred	534	17.2
[1]Wolf	1034	16.2
[3]Swan		29.0 littoral
		17.7 profundal

Data from

1. McDonald 1967, unpubl.
2. Turner 1967, unpubl.
3. Paterson 1968.

Over 80 per cent of the littoral region has a sand-gravel bottom type. This is significant in that certain types of bottom fauna are associated with this substrate and subsequently certain fish types may become more prominent as a result of diet suitability. In the comparisons from Table 37 the amount of bottom fauna is quite small in Seibert and this may be a result of the great abundance of sand and gravel in the littoral zone. The reduced nature of the amount of bottom fauna has an effect on the growth of fish that depend upon it.

Fishes

(a.) Lake Whitefish (*Coregonus clupeaformis*)

The lake whitefish of Seibert Lake are generally considered to be small in size (ie., a 9 year old fish is 400 mm. (15.7 in.) and 897.4g. (31.6oz.) in weight). Very few whitefish older than 10 years were sampled and the largest fish was just over three pounds. No whitefish of the "jumbo" size were found in the lake.

Seibert Lake whitefish have similar initial growth patterns as populations in other Alberta lakes but do not continue to increase (Table 38).

Lack of whitefish over the age of 9+ hints at some sort of exploitation or mortality of older age classes. The variation in size of whitefish between ages five and nine is very small and size range appears to suit the major predator in the system. The major diet of large northern pike is lake whitefish and the whitefish are being cropped at a rate which when combined with natural mortality results in few older age classes.

TABLE 38. Comparison of Growth of lake whitefish from various lakes in Canada (lengths in mm.).

Age Class	Seibert	[1]Buck	[1]Pigeon	[2]N.W.T.
1+	194.3	232.7	183.4	135
2+	271.7	313.2	244.7	165
3+	307.9	385.1	328.3	200
4+	347.8	441.4	357.3	245
5+	356.9	483.0	373.2	300
6+	374.6	502.3	379.0	340
7+	390.4			355
8+	394.4			390
9+	400.2			420

Data from

1. Bidgood 1972.
2. Environment Canada 1972.

Bidgood (1972) found that a lack of predators was one of the causes for reduced growth of lake whitefish at Pigeon Lake, Alberta. At Seibert, pike feed to a great extent upon whitefish but the growth of lake whitefish is not enhanced in the younger age groups. Pike do not appear to adversely affect or enhance growth of any age classes of whitefish. Other factors appear to control the growth pattern in whitefish.

The whitefish population appears to be very large as a result of large areas of sand and gravel where spawning takes place. The large numbers of fish suggest some intraspecific competition and this is enhanced by the relative amount of bottom fauna in particular that bottom fauna in the profundal zone.

Quadri (1961) indicated that whitefish move to deeper waters in the summer-to the hypolimnion- in response to warming temperatures in the epilimnion. This phenomenon may restrict the availability of lake whitefish as food source for northern pike unless the northern pike move to deeper areas, but northern pike are basically a fish of the littoral region (Threinen, 1969). This is not the situation in Seibert in that no thermocline develops in the summers. Also many observations have been made in late spring and mid-summer of lake whitefish in the shallows of the littoral zone. In July fairly large numbers of whitefish have been noted in the bay areas (S_5 and S_{13}) where water is covered with *Nuphar* and is less than 10 feet (3.0 m.) deep.

The majority of bottom fauna is found in the littoral regions thus whitefish feed most efficiently on the bottom in this lake zone. The major food item in their diet, the amphipoda, is the

most abundant organism in the littoral region (regions less than 15 feet - 4.5m). Table 7 and Figure 13 show the overlap of whitefish diet with abundance of bottom fauna in the littoral zone. Thus the lake whitefish are readily available to the northern pike in spring, summer and fall.

The close trophic relationship between pike and whitefish is made more evident by the cestode *Triaenophorus crassus* which uses the pike as a definitive host and the lake whitefish as one of the intermediates (Miller, 1952). The mean number of cysts per average sized whitefish of 24 oz. (680 g) is 5.17 and this emphasizes the relationship.

(b.) Walleye *(Stizostedion vitreum)*

Generally the walleye of Seibert are considered as being relatively small in size due to the fact that the majority of fish sampled (sample size 1074) were of the 5+, 6+ and 7+ age classes. When comparing these age classes with similar age classes from other lakes (Table 39), one notices the smaller sizes. Very few fish older than 10+ are found which also makes the overall size appear smaller.

McDonald (1967, unpubl.) shows the growth of walleye at Winefred Lake, Alberta as being generally greater than that shown in Seibert. Rawson (1957) in a study of walleye at Lac La Ronge, Saskatchewan indicated larger walleye with differences from Seibert beginning to occur from age 4+ to 5+, and with increased longevity; fish in the 13+ age class being present.

A sexual dimorphism, females being larger than males, occurs and this will be discussed in the section on northern pike.

TABLE 39. Comparison of growth of walleye from five lakes in Canada (fork length in mm.).

Age Class	Seibert	[1] Moose	[1] Winefred	[2] Lac La Ronge	[3] N. W. T.
2+		261		233.7	
3+	298.5	270		281.9	
4+	336.9	346		327.7	
5+	366.3	388	404	378.5	280
6+	399.8	465	421	424.2	295
7+	433.1	473	466.9	467.4	315
8+	479.2	498	487.6	508.0	359.8
9+	521.3	504	494.3	546.1	375
10+	554.5	516	530.6	581.7	380
11+			557.0	614.7	388
12+			554	645.2	395
13+				675.6	405

Data from

1. McDonald (1967).
2. Rawson (1957).
3. Environment Canada (1972).

Males have a shorter life-span than the females and this seems to fit the Rosa Lee phenomenon where early maturity results in decreased longevity.

Bidgood (1967) found that male walleye from Lake Athabasca, Alberta matured and spawned for the first time at age 4 and females at ages 4, 5 and 6. Looking south to Wisconsin most male walleye matured at age 2 to 3 and females at age 4 to 5 (Neimuth et al., 1959). At Seibert almost all the males (98%) mature from age 4 to 5; females are found mature in age classes 5+ (6%), 6+(56%) and 7+(90%).

Walleye of Seibert Lake spawn over the numerous sand-gravel areas of the lake. Neimuth et al. (1959) state that spawning occurs at night over gravel or broken rocks on windy lake shores or in tributary lakes. Some of the major spawning areas are on the east (S_{11} and S_{12}) and south-east shores (S_{14} and S_1) which receive the major wave action from the prevailing north-west winds. Spawning was related directly to water temperature and ice melting; in both years peak spawning occurred 8 to 9 days after the ice was completely gone from the lake.

Walleye appear to be very abundant in Seibert and their distribution is quite widespread in the littoral regions of the lake. Both walleye and whitefish converge upon the littoral zone for their food and thus some interspecific competition for space and food may occur.

(c.) Northern Pike *(Esox lucius)*

The growth of pike varies considerably with a number of factors which shall be discussed later. Table 40 compares growth in

TABLE 40. Comparison of growth of northern pike in nine lakes from various parts of the world (fork length in mm.).

Age Class	Selbert ♂♂	Selbert ♀♀	[1]Windermere ♂♂	Windermere ♀♀	[2]Floatingstone ♂♂	Floatingstone ♀♀	[3]Winefred	[4]Waskesieu	[5]N. W. T.	[6]Wisconsin	[7]Wisconsin	[8]Denmark
1+	293.6	293.6	230	230	205	205		224	94	495	208	85
2+	386.3	386.3	400	400	420	405		356	152	546	328	150
3+	480.8	514.3	520	550	475	510	573	445	234	594	391	205
4+	515.1	536.7	590	640	503	535	615	513	315	686	439	290
5+	555.1	620.8	630	700	525	555	666.7	559	389	734	483	380
6+	582.9	704.3	650	760		591	652.4	602	449	803	526	440
7+	651.0	779.2	660	800		619	761	663	508	889	559	505
8+	745.6	849.7	680	840		681	802	724	564	947	683	545
9+	730.5	938.8	690	880		690		787	612	1006	752	
10+	715.3	1002.0	700	900					658	1125		
11+	*862.3	961.3	720	930					701	1138		
12+	*785			960				965				
13+	*903.5	1010										

*small sample size, all appeared sterile

Data from

1. Frost and Kipling (1967).
2. Robertson (1969).
3. McDonald (1967).
4. Scultz (1953)
5. Miller and Kennedy (1948)
6. Van Engel (1940)
7. Snow and Beard (1972)
8. Pahl (1963)

length with that found in other studies. This table also shows a comparison between the growth of males and females in Windermere, Floatingstone and Seibert. The growth in northern Canada (Miller and Kennedy, 1948) is extremely slow in comparison to Wisconsin lakes (Van Engel, 1940). Valuable comparison with Seibert are lakes of similar latitude such as Floatingstone (Robertson, 1969), Winefred (McDonald, 1967) and Waskesieu (Schultz, 1953). The Seibert pike tend to grow in a rather restricted fashion until they reach an age of five. After this point is reached growth is very rapid and leveling does not appear to occur as it does in Floatingstone and Windermere. Growth may slow down after age eleven but few fish over this age were sampled.

Males and females show a dimorphism in terms of growth. This sexual dimorphism is much more evident in older fish but the author has sampled a few large sterile males. Frost and Kipling (1967) in the study on Lake Windermere show differential growth being noticed at age three. Many researchers indicate that females grow faster than males (Healy 1956, Brown and Clark 1965, Solman 1945, Carbine and Applegate 1948). Miller and Kennedy (1948) found that females lived longer than males though they were no larger age for age. From tagging data the author notes pike of age 9 being 600 mm. in length and weighing only 1589 g. or 3.5 pounds. No females of this age were found this small nor did they have characteristics of large heads, thin bodies and large scales. The only males found older than nine were not of this stunted form but large and sterile.

There appears to be a couple of evolutionary advantages to such a sexual dimorphism. First, females are of greater importance in producing more successful young as a result of egg characteristics

such as number, size and chemistry (Nikolskii, 1964). Secondly, a species develops adaptations such as dimorphism that widen the species food supply and this is particularly noticeable in Seibert. Kawanabe (1958) suggested that poor food supplies resulted in greatest sexual dimorphisms in populations and this could be a result of behavioural differences between the sexes.

At Seibert it appears that after spawning, females are more aggressive as a result of a greater physiological stress as compared with the male. Males are thusly competing with the more aggressive females for prime feeding areas. The females regain their lost weight and put on weight while the males must expend energy in areas not as productive. The females may then select or retain prime habitat for the summer and fall while males continue to regain and increase weight. This phenomenon would be enhanced each year and the differences would become more outstanding. The mechanism would also explain the walleye situation where females are significantly larger because of this increased aggressiveness from physiological stress due to spawning. The constant pressure on the males because of less efficient feeding probably has an effect on the longevity of males as opposed to females. In the case of the walleye this was very pronounced in that no males over the age of 8+ were to be found.

A comparison of the frequencies of age classes of pike sampled from angler catches and pike sampled from tagging indicates forty per cent of the angled pike were of the age classes 7+ and 8+; while forty per cent of the tagged pike were from age classes 3+ and 4+. Tagging was carried out on a purely non-selective basis in which all

pike captured were considered in tagging. This was a basic reason for keeping an accurate count of pike releases and where they were being released. Another important point is that all the tagged pike were caught in the July-August period while the large trophy fish, being most active in the spring, are almost entirely taken in May and June. These observations must be considered in the future management of the northern pike.

Another interesting aspect of comparison between tagged pike and angler caught pike are the growth curves (Figures 22 and 30). For each age class tagged pike show a size between that of males and females but in many age classes the size is closer to the male size. From tagging returns males were more abundant (sex ratio 1.2:1.0) which would substantiate the bias in the growth curve comparison. This indicates that in most studies on pike a separation of data should be made between the sexes, so as not to bias growth curves due to unequal sex ratios. Unequal sex ratios are definitely possible when considering differences in activity, in distribution and in season or in time.

Age of maturity varies with latitude, in Great Bear Lake (Miller and Kennedy, 1948) pike mature at age five or six and in the south in Wisconsin males are mature at two and females at three (Threinen et al., 1966). Frost and Kipling (1967) at Windermere related maturity to length rather than age. In Selbert most males will spawn at age three and most females at age four.

Spawning occurs just as the ice is beginning to leave the bay areas at the end of April and early part of May. Threinen et al.

(1966) found the same in Wisconsin and states that pike spawn in water less than 12 inches (30.5 cm.) over flooded emergent vegetation. The type of vegetation used by pike is contradictory. Brown and Clark (1965) in work in Ohio and Frost and Kipling (1967) in Windermere claim that pike use *Myriophyllum* and the latter claims as deep as 2.4 m. or 7.9 feet. Nikolskii (1964) states that eggs deposited on growths of *Myriophyllum* experience good oxygenation and die only in small numbers. Franklin and Smith (1963) mention a number of undesirable plants for pike spawning including *Myriophyllum*. They mention the use of *Eleocharis*, *Carex* and *Equisetum* which are normally emergent plants. In Selbert spawning areas vary a great deal in quality from a "poor" area which contains only flooded or fallen *Scirpus* to "prime" areas (S_5 and S_{13}) which contain *Carex*, *Equisetum*, *Eleocharis*, *Myriophyllum*, *Ceratophyllum* and *Drepanocladus*. Fabricius and Gustafson (1958) mention dense short vegetation as well as flooded marsh vegetation and thus appears to describe the prime spawning areas in Selbert.

Generally to combine the ideas of most researchers mentioned above, one could say that the optimum spawning habitat for northern pike is a bottom with a dense mat of short vegetation. This vegetation acts as a stimulus and as a substrate in the spawning act. The hatching young-of-the-year attach themselves to plants and debris by means of a sticky secretion from the head. The offspring remain in this dense vegetation and shallow water for protection from predators. Selbert Lake has limited areas of prime dense vegetation and thus those outside this vegetation belt experience increased mortality.

From the tagging data it was shown that movements in pike are very limited and may even be considered territorial, especially after spawning occurs. Miller (1948) at Square Lake Alberta indicated that during spawning periods in the spring the pike may move around a great deal even to go across open water (one to two miles). Franklin and Smith (1963) said that pike exhibit no homing tendency for particular spawning grounds. Wistrom, Apelgren and Threinen (1957) say that after spawning the pike becomes solitary and almost territorial. This information tends to support the observations made at Seibert Lake. In some lakes such as Floatingstone Lake, Alberta (Robertson, 1969) there is a migration of pike up incoming streams to shallow lagoons or sloughs in which spawning occurs. This congregation at the spawning grounds has been noted by many surveys in Western Canada. Spawning success may be related to the presence of streams and lagoons which tends to congregate the spawning adults. In lakes where spawning is not united in a common area, then overallsuccess is impaired. Spawning of pike in Seibert has been observed in a number of areas around the lake. The overall effect may be smaller populations. Threinen (1969) comments that pike appear to reach their greatest abundance in lakes with inlets.

Since very little movement was noted in pike at Seibert and since differences between pike from different lake zones was observed, the microenvironments were examined to see why pike were distributed as they were. Frost and Kipling (1967) noted that pike of 23 - 100 mm. in aquaria tended to live a discrete distance from others and suggested spacing and intraspecific competition for that space. Frost and Kipling also suggested that pike may spend

their lives in places which are conducive to better growth than that occupied by their neighbors and this is reflected in their relative sizes.

The differences in pike growth from different lake zones was examined to see if statistically significant differences do occur between pike of different areas. Figure 44 shows the growth differences of pike aged 3+, 4+ and 5+ in four lake zones, S_5, S_7, S_{13} and S_{14}. In S_5 and S_{13} growth to 3+ is slow. This may be due to the large production in these prime spawning areas and the resulting intraspecific competition. The opposite extreme is S_7 where poor spawning habitat may result in little production thus pike of 3+ are much larger then those in S_5 and S_{13}. Growth continues to occur quite rapidly in S_7 zone but few older pike are found. In S_5 and S_{13} growth occurs more rapidly and many older pike are found. Zone 14 is quite unique. In this zone pike growth levels off from age 4+ to 5+ and continues to level off in older age classes. The growth differences appear to fit the Rosa Lee phenomenon which has been investigated by Bryuzgin (1961), Shentyakova (1962) and Zarnakhaev (1964). This phenomenon appears to indicate that fish which grow rapidly in early years (especially the first year) are less abundant in later years while the slow growers tend to live longer. Some suggest that there is a greater selection against these fish and also that a higher rate of metabolism in early years affects longevity.

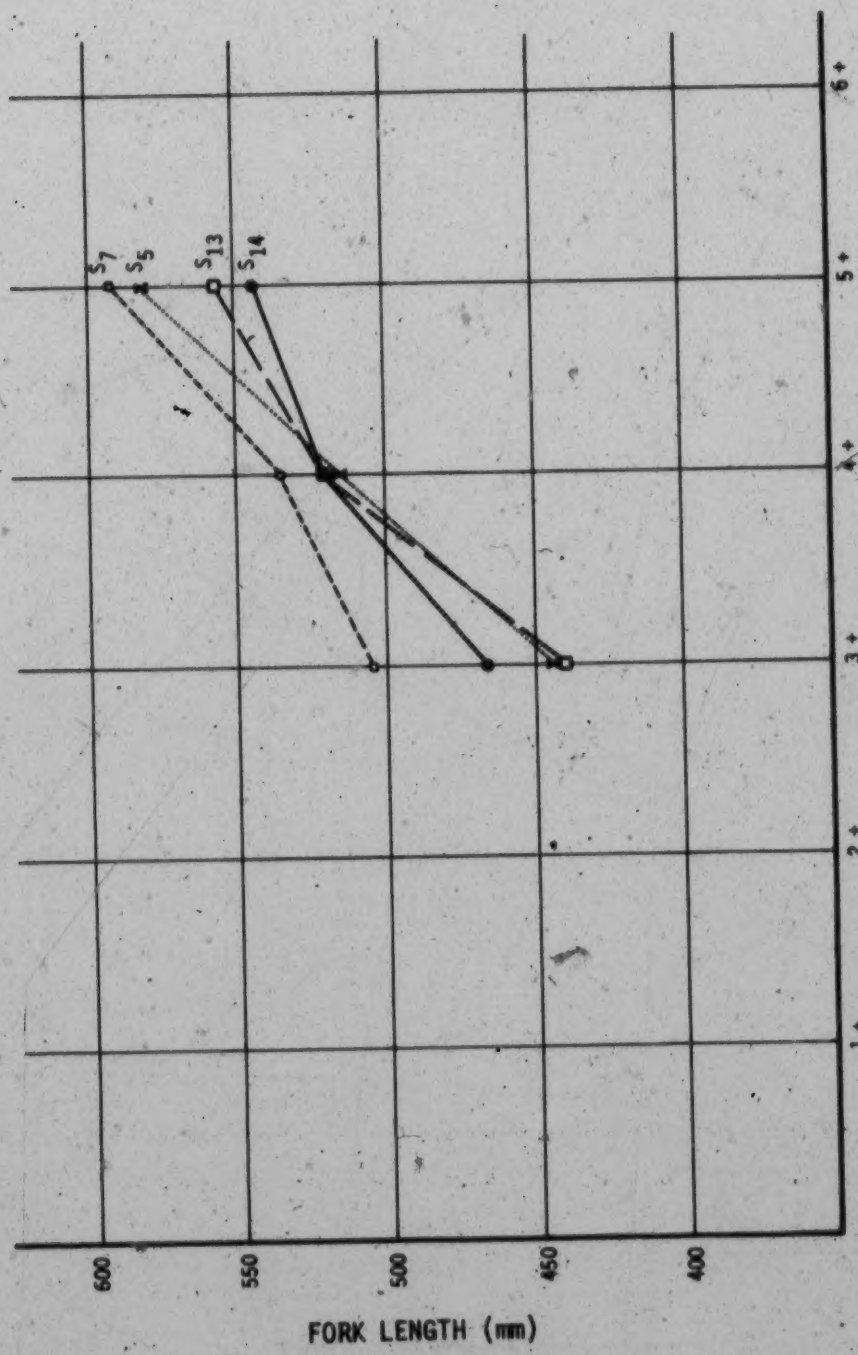


FIGURE 44 DIFFERENTIAL GROWTH OF PIKE FROM DIFFERENT LAKE ZONES.

Interaction of Fish Populations

Odum (1966) defines interspecific competition as "those interactions in which each population adversely affects the other in the struggle for food, nutrients, living space or other common need." Odum also notes that differences in growth curves may be an indicator of competition. Food abundance is an important factor when considering growth of particular individuals of a population. Other factors are important in growth and some will be mentioned in later sections.

The major food items of lake whitefish have been documented by Quadri (1961), Paetz (1972), Bidgood (1972) and numerous general surveys in Alberta including McDonald (1966 and 1967) and Turner (1967). Chironomid larvae (*Tendipes*) and molluscs (clams in particular) appear to be the most common food items in most of the studies mentioned. At Seibert, whitefish use amphipods more than any other item followed by chironomids and molluscs and then by mayflies, caddis flies and leeches.

Lake whitefish at Seibert are found more in the littoral zone than whitefish in most other lakes (Quadri, 1961). Amphipods are the most abundant organism in the littoral zone as well as being the major food item in the diet of the whitefish. Over twenty per cent of the whitefish feed on leeches which are most abundant in littoral zones. Mayflies were only found in the littoral zone and again over twenty per cent of the whitefish feed on them.

Walleye feed mostly on fish and invertebrates (Paetz and Nelson, 1970). Rawson (1957) found at Lac La Ronge, Saskatchewan that 97 per cent of walleye have fish as part of their diets.

McDonald (1967) found at Winefred Lake nearly 90 per cent of the walleye diet is fish. Amphipods are found in 60 per cent of all walleye stomachs from Seibert. Fish form 40 per cent of the walleye diet in Seibert; mayflies form 35 per cent of the walleye diet.

An aspect associated with rather slow growth of the walleye is the lack of any major fish items in their diets. Hoogland and Tinbergen (1956) made some interesting behavioural observations on pike and walleye and the food which they consume. They observed a definite avoidance of sticklebacks as a prime food item. It appears that after taking some sticklebacks, mouths are hurt and thusly pike and walleye become negatively conditioned. The major fish food of walleye in Seibert is the brook stickleback, thus it appears to be the most abundant forage fish which suits the walleye in a reserved fashion. The short spines of *Culaea* may be a factor of importance when considering the actual avoidance of predators.

Walleye and whitefish converge upon the littoral regions of Seibert to derive most of their food requirements. A close examination of how the diets of the whitefish and walleye overlap is indicated in Figure 45. Amphipods, mayflies, caddis flies and leeches are important food items found most abundantly in littoral regions. Major food items which do not overlap include dipterans and molluscs which are fed upon by the whitefish and fish which are fed upon by the walleye.

Interspecific competition seems to be indicated and this may be a partial reason for the slow growth rates of the walleye and the whitefish. With large populations of both these species due to large spawning areas, with overlap in lake distribution both in

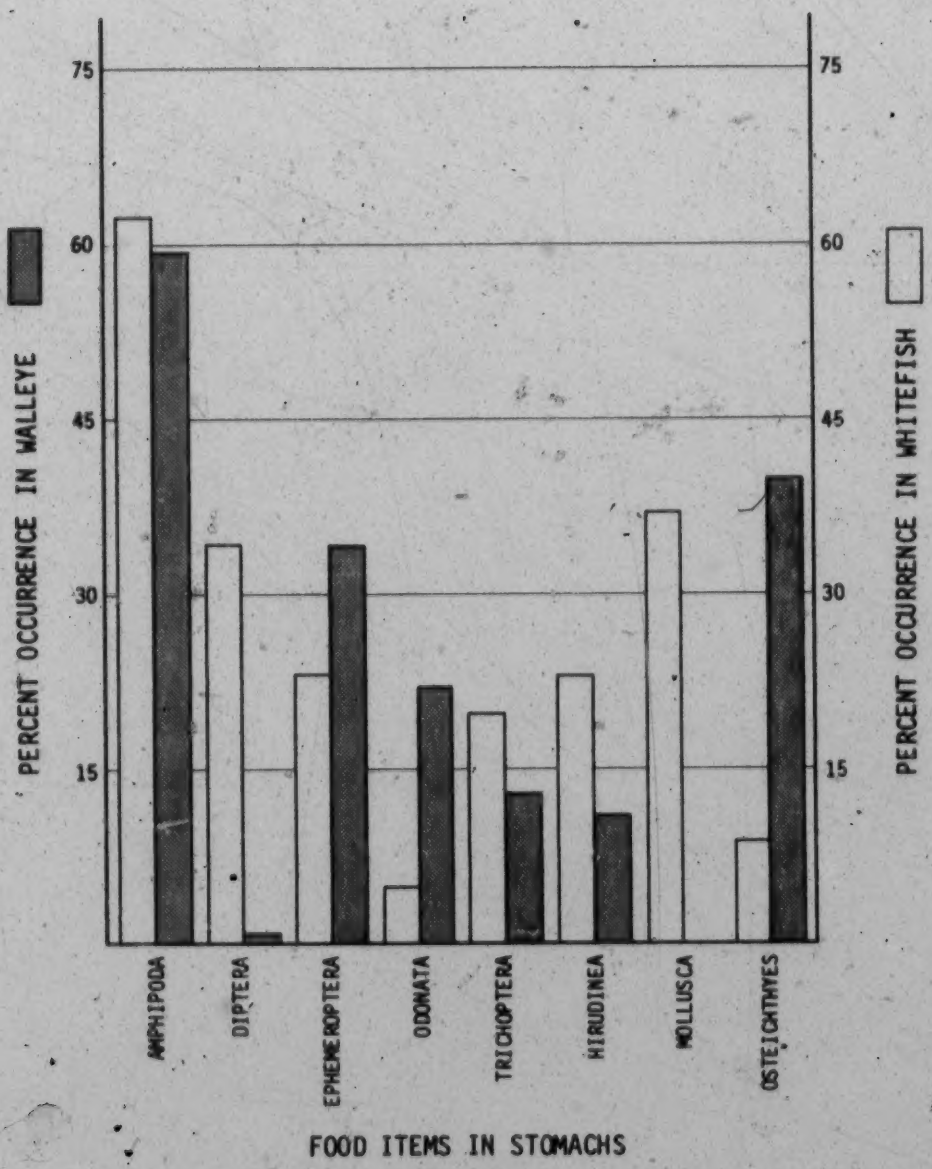


FIGURE 45 COMPARISON OF THE DIETS OF LAKE WHITEFISH AND WALLEYE FOUND IN SEIBERT LAKE.

littoral zone and with overlap to some degree in diets , the interspecific competition is realized and the intraspecific competition is enhanced. These are reasons which support the statement that walleye and whitefish of Seibert are stunted or a relatively small size.

Ricker (1963) claims that even slightly exploited populations have noticeably fewer older fish and that in some cases younger age groups grow more rapidly. In Seibert both whitefish (by pike) and walleye (by anglers) appear to be exploited. As a result few older fish are found but in both cases growth does not appear to be enhanced in younger age groups. This would imply that the above mentioned growth limiting factors act together to prevent increased growth or that exploitation is not very great.

Another aspect to consider in terms of trophic structure is the diet of northern pike in relation to the diets of whitefish and walleye. Smaller sized pike feed to a great extent on amphipods, brook sticklebacks, dragonflies, damselflies and leeches. Amphipods were the most commonly found food item in pike less than six pounds (2724 g.). Since the major food item of both whitefish and walleye are amphipods, one may implicate that an abundance of these crustaceans are found in Seibert (as was shown) and that possibly some interspecific competition among these three species of fish does occur. Frost (1954) at Windermere found very few invertebrates in the pike diet although a few amphipods were eaten. But Larsen (1951) in Danish streams found a high frequency of amphipods (*Gammarus*) in pike of 20 - 46 cm. where pike were considered to be a serious competitor with trout for this food.

Figuire 46 shows the overall trophic structure in relation to the three major fishes. The chart shows that whitefish seem to feed on a number of different food items while large northern pike (those greater than six pounds) feed almost exclusively on one food item, whitefish. Beyerle and Williams (1968) indicate that pike prefer soft-rayed fish as opposed to spiny-rayed fish. In Seibert the selection is obvious but conditions which must also exist are: overlapping distributions of predator and prey and a proper size of prey that makes feeding the most efficient.

The average numbers of organisms found per stomach containing food in the major fishes are:

lake whitefish	51.4
walleye	15.7
northern pike	5.3
large (greater than 6 lb.)	1.0
small (less than 6 lb.)	11.5

This comparison indicates the relative position of the fish species in the food web; the fewer the number of organisms per stomach the higher the position in the trophic pyramid.

Table 41 indicates a comparison of the major food items of northern pike in a number of different studies. Few researchers have found that coregonine fishes make up a major part of the diet of pike even when present in the lake. Lawler (1965) found that more coregonines were taken when pike inhabited deeper parts of the lake as in the summer. Lawler also stated that the abundance and availability of a food item determined its incidence as prey. Johnson (1966) found a tendency of pike to take small prey (other

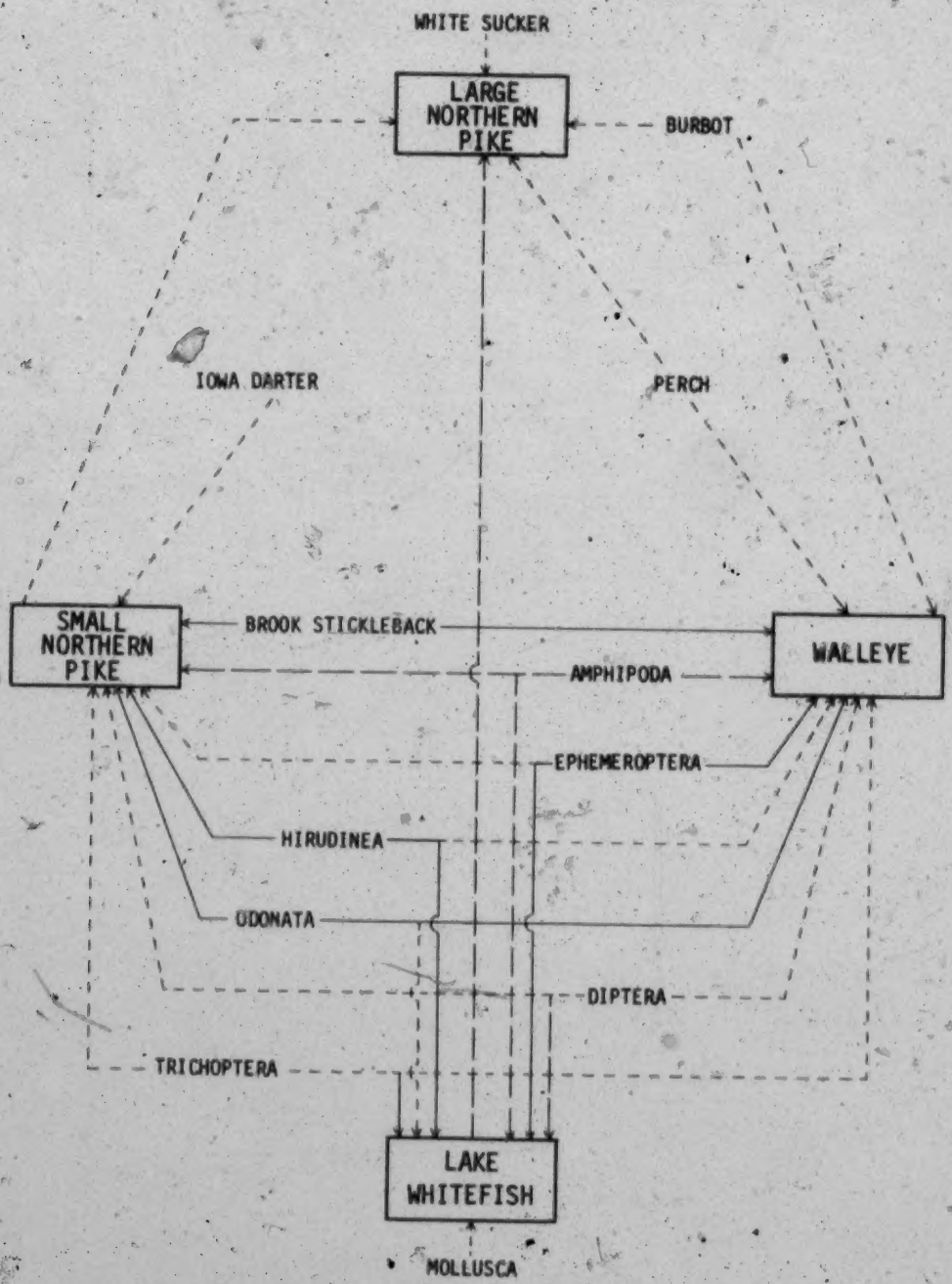


FIGURE 46 TROPHIC STRUCTURE FOUND IN SEIBERT LAKE.

TABLE 41. Comparison of major food items of northern pike from six lakes

Lakes	Lake Whitefish	Others
Selbert	Major food item	
Heming (Lawler, 1965)	Very minor	Trout perch, Perch
Windermere (Frost, 1954)	None present	Perch, Three-spined stickleback
Murphy Flowage (Johnson, 1966)	None present	Bluegills, Perch
N. W. T. (Environment Canada)	Approx. 10% Coregonines	Longnose suckers, Burbot, Pike Arctic Grayling
Lesser Slave Lake (Zelt, Person. Commun.)	Very minor	Tullibee, Burbots

fish) if present and suggested that this may limit growth. At Seibert small numbers of small forage fish are found and this may be a reason for fairly slow growth of pike between two and five years of age. The larger and older pike find few small forage fish to feed upon which if present may limit their growth but they do find numerous lake whitefish.

Beyerle and Williams (1968) found pike to be selective in the type of food which they ate. Large populations of appropriate soft-rayed food fishes favored good growth in pike. Beyerle and Williams also claimed that large numbers of soft-rayed fishes of small size resulted in rapid growth to 15 in. (381 mm.) and large populations of large soft-rayed food fishes yielded maximum growth of large pike. At Seibert slow growth was noted to the age of five after which (females in particular) the pike grew very rapidly. Few soft-rayed fishes of small size are available to the pike as indicated by their stomach contents and generally few small forage fishes are present. Brook sticklebacks appear to be the most common of these fishes but their distribution is limited. From all the whitefish found in pike stomachs 93.5 per cent were over the age of five. Younger whitefish (less than five years) appear to be distributed differently than the older or possibly the older whitefish become easier prey for the pike.

Another consideration is the growth rate of the whitefish in that slow growers are fed upon by predators much more extensively than fast growers. Thus pike are able to feed on a large number of age classes in any given year.

Frost (1954) and Lawler (1965) claimed that predation is a major factor influencing the abundance of a species and its population properties. Bidgood (1972) suggested predation to be a major factor in the changes in lake whitefish population structures in a comparison of two Alberta lakes. In Selbert the population structure of the whitefish indicates that few fish over the age of ten are found thus pike are influencing the abundance of whitefish of older age classes. This exploitation of a fish population was studied by Ricker (1963) who indicated that a five per cent catch or removal per annum causes major reduction of older fish.

The major fish species concentrate their main activities in the littoral zone of the lake. Pike and older whitefish overlap to a great extent but it appears that whitefish are more widely distributed throughout the lake. Also whitefish younger than five appear to be quite abundant in areas of open water over the profundal zone. Walleye are also more widely distributed than the pike which is limited to a few areas of the lake.

This distribution phenomeon tends to indicate habitat characteristics of Selbert; the great abundance and wide distribution of gravel and sand areas tend to relate walleye abundance while limited silt-organic bottom and thus certain vegetation types relates to pike abundance being limited to certain areas.

Habitat Quality in Relation to Characteristics of the Pike Population

In this section of the discussion I will relate the differences in total environment with the 14 lake zones. With the aid of locational catch differences of both walleye and pike, with the aid of bottom faunal differences at the ten foot (3.0m.) depth and with the aid of overall vegetation diversity I will indicate reasons for pike distribution and the characteristics of those pike within a given zone.

Table 42 indicates the data used in the correlation analysis. The presence of *Nuphar variegatum* (Yellow Pond Lily) seemed to be significant as an agent relating to pike abundance and thus is included in the table.

Table 43 indicates the various variables used and the subsequent correlative strength of the relationship. Pearson's correlation coefficient (r) was used as well as Spearman's rank correlation coefficient (rs). The reason for both analyses was to obtain a more critical coefficient using Pearson's statistic which requires that variables be normally distributed and Spearman's as a method used in simple ranking, thus not considering actual values. The correlation coefficients showed more or less the same things. The abundance of pike was inversely related to bareness ($r=-.72$ and $r_s=-.81$). The high degree of bareness in Seibert tends to suggest that the size of the pike population is quite small since a great part of the lake shore lacks submerged vegetation. The correlation between pike abundance and bottom fauna is slightly positive but quite weak. Previously it was noted that certain types of bottom fauna were found in areas where pike were abundant.

TABLE 42. Characteristics of lake zones in Seibert Lake.

Zone	% Angled Pike	% Tagged Pike	% Angled Walleye	Bottom Fauna Weight	Vegetation Diversity	Bareness	Pike Habitat Quality	Nuphar
S_1	1.5	1.4	13.5	14.6	.10	90	.55	
S_2	1.3	5.3	4.5	14.4	.50	58	2.53	
S_3	3.5	13.6	1.8	12.5	1.10	18	3.85	x
S_4	0.4	1.1	0.1	12.3	.95	45	3.15	
S_5	30.6	15.5	8.6	27.3	1.89	25	5.65	x
S_6	0.2	0.5	0.05	23.0	.17	83	1.57	
S_7	3.9	5.4	5.8	13.1	1.06	37	3.95	x
S_8	9.8	14.8	8.9	13.8	1.02	38	3.83	x
S_9	11.2	15.1	9.0	16.6	.95	30	4.35	x
S_{10}	2.2	3.5	2.5	15.1	.72	45	3.14	
S_{11}	0.04	0	3.8	5.8	0	100	.10	
S_{12}	0.4	1.2	2.3	6.7	.69	44	2.13	
S_{13}	32.2	18.9	8.8	11.8	1.05	35	3.16	x
S_{14}	2.7	3.9	30.1	13.8	.30	80	1.30	x

TABLE 43. Correlation of pike abundance to various habitat factors.

Variables	Pearson's (r) Correlation coefficient	Spearman's (rs) Correlation coefficient
Tagged pike vs Bareness	-.72	-.81
Angled pike vs Bareness	-.49	-.78
Tagged pike vs Bottom fauna	+.29	+.24
Tagged pike vs Vegetation diversity	+.73	+.78
Angled pike vs Habitat quality	+.58	+.77
Tagged pike vs Habitat quality	+.73	+.79

Bottom fauna such as odonatans and hirudineans are found in certain vegetative associations with large populations of pike.

Considering the various plants found within a given area and indicating how important they are to pike populations the numbers of tagged pike correlate in a direct relationship with habitat quality ($r=+.73$ and $r_s=+.79$). Vegetation diversity also correlates positively with pike abundance.

The tagged pike abundance figures appear to correlate better than the angled pike abundance figures. This is indicative of an attempt to be random and non-selective in the tagging program. Anglers tend to be selective and thus go where the greatest number of large fish are present.

Threinen (1969) commented about the significance of various types of aquatic vegetation in maintaining temperature. He states, "The thick weed bed prohibits vertical mixing, absorbs heat and provides cooler water. Certainly the clone of water lilies with leaves on the surface must have some effect on both heat absorption and water mixing locally." Water lilies are extremely important in the habitat requirements of large pike but other types such as white-stem pondweed (*Potamogeton praelongus*) and floating pondweed (*Potamogeton natans*) are also very important. Shade is an important factor but almost more important is the protection aspect. A well vegetated area will adequately house more pike of small size but more importantly there must be a certain amount to house a large pike. A well protected area will allow a pike to expend less energy in activities other than feeding. A pike in a well vegetated area is possibly much more successful in his feeding ventures when he is able to wait

in a well hidden spot and thus let the food come to him.

Pike in a lesser habitat quality may expend more energy in seeking protection from other pike and therefore will be less effective in capturing prey. The poorer the vegetative habitat the greater spatial requirements of each individual.

Lake zone S_4 has a fairly diverse vegetation but the pike population appears to be quite small. This may relate to production. Pike movements are limited in Seibert thus with little spawning in this zone few fish become summer residents.

Lake zone S_6 has a tremendous amount of bottom fauna but few walleye or pike appear to be captured in this zone. Large schools of lake whitefish were observed and possibly this was the major fish in the area.

In table 44 each zone has been given a rating as to abundance of fishes and habitat quality. A top rating in any subject was given a IV while the lowest rating a I. In the last column is a general evaluation of each lake zone as to the trophy nature of the pike population. Composites of certain vegetation types support fairly large pike. These areas are of limited size and number when looking at the entire lake. Prime zones for trophy pike are S_5 and S_{13} but large numbers of pike are found in S_5, S_8, S_9 and S_{13}.

The table indicates that S_{11} is the least suited area for pike with the least amount of bottom fauna, least vegetation diversity, smallest pike habitat quotient and most barren habitat.

Prime walleye areas tend to be more on the barren side as indicated by S_1 and S_{14}. The walleye are more generally distributed with only two zones rated I on the four point scale. Pike have five

TABLE. 44. Factors which best select for northern pike rating I-IV (I being lowest; IV being highest).

Lake Zone	Abundance of Pike	Abundance of Trophy Pike	Abundance of Walleye	Bottom Fauna	Vegetation Diversity	Lack of Bareness	Pike Habitat Quotient	Trophy Pike Habitat Evaluation
S_1	I	I	IV	III	I	I	I	None
S_2	II	I	II	III	II	II	II	One very small area
S_3	III	II	II	II	III	IV	III	One fairly large area
S_4	I	I	I	II	II	II	III	None
S_5	IV	IV	III	IV	IV	IV	IV	Prime area (bay)
S_6	I	I	I	IV	I	I	II	None
S_7	II	II	III	II	III	III	III	Two limited areas
S_8	IV	III	III	II	III	III	III	Five fairly extensive areas
S_9	IV	III	III	III	III	III	IV	Five fairly extensive areas
S_{10}	II	II	II	III	II	II	III	Two limited areas
S_{11}	I	I	II	I	I	I	I	None
S_{12}	I	I	II	I	II	II	II	One small area
S_{13}	IV	IV	III	II	III	III	III	Prime area (bay)
S_{14}	II	I	IV	II	II	I	II	One limited area

zones rated 1.

From this table a correlation was made between pike abundance and the habitat quality quotient. Correlating trophy pike abundance to habitat quality yielded an r=+.76 where as the correlation between pike abundance and habitat quality r=+.97. This indicates that other factors besides vegetation itself play an important role in determining whether large pike will exist in an area. In a few movements of tagged fish an interesting trend was noted. For example, a female pike aged 5+ and tagged in S_2 moved from this zone of rather limited pike habitat to S_5 a zone of prime habitat. She was returned two years after tagging at age 7+ and weighed eleven pounds (4994 g.). The trend, from the 22 per cent moving fish, was a movement of pike of a size, similar to the example, in search of seemingly more suitable habitat to protect or house their larger bodies.

There is no doubt that the largest pike tend to live in the "best habitat" and this may imply a competition (intraspecific) for this habitat. But other factors must be considered in the overall analysis of why pike grow so large at Seibert Lake.

Factors Yielding "Trophy Pike" at Seibert Lake

A number of factors appear to be responsible for the growth of pike in Seibert. These factors act together and with a change in any one factor, growth may be altered. Lakes which produce numbers of large pike would appear to also have a series of interrelated factors which would allow a great deal of the energy entering the trophic level to be directed towards growth. There are three major factors which are qualified by other factors and they are listed below.

1. A small northern pike population (20,400 over the age of two) results in a lesser intraspecific competition thus a reduction in the amount of energy expended in the direction of spacing or pike interaction with other pike. The small population is a result of:

   (a.) limited spawning habitat thus poor recruitment.

   (b.) general lake spawning. Threinen(1969) noted larger numbers of pike in lakes with inlets in which pike tend to synchronize spawning activities thus resulting in increased production.

   (c.) general poor pike habitat which would have a negative affect on the survival of young pike. The amount of good pike habitat is limited.

2. Areas of prime pike habitat are necessary for the very large pike. A certain vegetative quality, vegetative diversity and vegetative association allows for better growth in that less energy is expended in the attainment of food and less energy is expended in competing with others.

3. A whitefish population acts as the major food supply for the large pike. A number of factors make the whitefish very important to the pike:

   (a.) the whitefish is the choice or the most desirable of the fishes available. Pike have a preference for soft-rayed fish (Beyerle and Williams, 1968).

   (b.) their distribution overlaps with the pike because of certain limnological factors. The whitefish distribution differs from that found in most lakes (Quadri, 1961). A relative abundance of littoral zone bottom fauna also acts to move whitefish into shallower water.

(c.) the whitefish is very abundant as a result of high production from the numerous spawning areas in the lake.

(d.) the size of the whitefish complements the size which can be taken by the pike, thus one could say that the size is appropriate for near maximal pike growth. The whitefish are slow growers thus making a large percentage of the older population available to the pike. The reasons for the rather small size (nine year old fish less than two pounds) are three-fold: a limited bottom fauna even in the littoral zone, a large population of whitefish thus increased intraspecific competition and a large population of walleye that feed in the littoral zone on comparable foods to the whitefish results in interspecific competition. The walleye are also affected by the whitefish competition and this is noted in their relative small size.

The importance of any one factor in relation to another factor may be looked at with a number of "if" statements. If the production of pike was increased then a pike would expend more energy competing with other pike thus less energy placed into growth. If a certain vegetation type for pike habitat is not present, large pike would expend more energy in interacting with other pike and in feeding (less efficient) and thus less energy would be placed into growth. If the whitefish grew faster possibly as a result of reduced whitefish numbers, as a result of reduced walleye numbers or as a result of an increased bottom fauna, then the suitable pike food supply would no longer be appropriate and growth would suffer. The limnological factors which force the whitefish to overlap with the pike in the littoral zone if changed would alter pike growth. Table 45 summarizes in a series of

flow charts the various factors and how their alteration would affect pike growth.

The growth of pike is comparable to growth in other pike populations up to age 4+. However, even in Seibert, populations in certain areas of the lake show growth differences to the age of four. Where production appears to be small, growth is rapid as in S_7. Domanevskii (1963) comments that the factors most limiting the actual number of harvestable fish produced are the conditions affecting the survival of the young. The habitat for actual spawning and housing of the young pike is of prime importance. The result of reduced production could result in lessening the intraspecific competition and thus the growth of individuals may be enhanced.

Pike growth in the bay areas where production is high is slow to begin with. As pike age in these areas where habitat is prime (S_5 and S_{13}) they begin to grow more rapidly. The habitat factor is important for a number of reasons already mentioned. These factors relate to energetic expenditures in that where an individual is in prime habitat a greater percentage of incoming food will go into weight gain rather than other energy expending metabolic activities. Johnson (1966) said in a study of Lake Windermere that pike have relatively low maintenance requirements and relatively high values for the conversion of food to pike substance. As habitat conditions become optimal the maintenance requirements decrease.

It appears that there is an active search by rapidly growing pike for prime habitat. If they are unsuccessful in finding an area of prime habitat, then they expend a great deal of energy in a lesser area or in the continued search. With angler exploitation fish

TABLE 45. Result of alteration in factors responsible for pike growth (↓ decrease; ↑ increase)

1. Number of whitefish ↓ → Pike growth ↓

2. Number of whitefish ↓ → Intraspecific competition of whitefish ↓ → Whitefish growth ↑ → Pike growth ↓

3. Number of walleye ↓ → Interspecific competition (whitefish and walleye) ↓ → Whitefish growth ↑ → Pike growth ↓

4. Number of pike ↑ → Intraspecific competition ↑ → Pike growth ↓

5. Poor pike habitat → Intraspecific competition ↑ → Movements ↑ → Feeding success ↓ → Pike growth ↓

6. Number of forage fish ↑ → Walleye diet changes → Interspecific competition (walleye and whitefish) ↓ → Whitefish growth ↑ → Pike growth ↓

7. Littoral zone bottom fauna ↑ → Whitefish growth ↑ → Pike growth ↓

8. Profundal zone bottom fauna ↑ → Whitefish growth ↑ → Whitefish distribution altered → Pike growth ↓

generally move into vacant areas with little difficulty. It appears that fish which remain in poorer habitats are generally of reduced size for that particular age class.

Table 46 illustrates some of the situations concerning growth which actually exist in Seibert.

Public Utilization and Suggested Management

A number of factors are responsible for the growth of pike. If these factors are unaltered, growth rates whould remain the same. But in order to maintain a fishery for years and years to come, one must look at the numbers of fish which may be removed. Thus one must look at the rates of exploitation by anglers.

A number of observations of note must be stated:

1. Interest has increased almost two-fold each year since the conception of the trophy lake idea in 1970-71.
2. The numbers of northern pike being taken has increased: 300 (1971 four months), 432 (1972 four months) and 522 (1973 two months).
3. The types of pike being taken still include many large pike but are beginning to include many more smaller pike.
4. The number of pike over the age of seven without any exploitation would be approximately 4000. The number of females (sex ratio 1 : 1) which form most of our trophy pike would be 2000. There would be approximately 600 females aged 7+ entering the population each year if no increased mortality occurs in younger age classes.

TABLE 46. Seibert Lake zonal situations with respect to northern pike. (↓ decrease; ↑ increase)

Spawning Habitat	Production	growth to 3+	Number of Pike	General Habitat Quality	Numbers of Pike	Trophy Pike	Zones
Prime	↑	↓	↑	Good	↑↑	Many	S_5, S13
				Poor	↑	Some	S_8, S_9
Poor	↓	↑	↓	Good	↓	Some	S_3, S_7, S_{10}, S_{14}
				Poor	↓↓	Nil	S_1, S_2, S_4, S_6
							S_{11}, S_{12}

Considering the increased public interest, the rather limited numbers of pike as well as the large numbers of pike being released it appears that certain managerial steps are necessary to maintain the large pike. Keeping in mind the increasing interest, the following suggestions are to be considered.

(a.) Close the fishery for pike every second year. This has disadvantages in that the crowding of people would occur in the open years.

(b.) Limit the number of trophy licences sold each year

(c.) Close the lake to angling in the month of May. This would allow bay areas to grow in with *Nuphar* and other vegetation, thus large pike would be less vulnerable. It would also allow the females to regain some of their weight after spawning.

(d.) Some mortality occurs as a result of the large numbers of fish being released. Possible regulations which may reduce this mortality factor include prohibition of bait, gaphs and barbed hooks.

With the very limited and sensitive fishery resource (trophy fish) it would be beneficial to manage most carefully and strictly at the present so as to maintain large fish for future anglers. It seems that with increased exploitation of other lakes the trophy fish will become a rare prize. As something becomes out of the ordinary more people will search for or desire a place where trophies may be captured. This means that in future years the designated trophy lakes will be subjected to even greater pressures. Seibert being more accessible than others may get the greatest amount of pressure.

CONCLUSIONS

1. Lake whitefish and walleye have large populations while pike have a small population.
2. Lake whitefish and walleye overlap in distribution and in diets.
3. Tagging affects growth of small pike more than large pike.
4. Pike are territorial in Seibert Lake. Movements are limited to special cases which appear to occur in the winter or early spring.
5. Because of the sexual dimorphism in pike, growth data should be presented with males and females kept separate.
6. Different growth rates of pike occur in different areas of the lake.
7. Differences in the amount of bottom fauna in profundal and littoral regions are quite large. Bottom fauna data should be kept separate.
8. Pike abundance is inversely proportional to bareness. A large part of the lake is barren thus resulting in a small pike population.
9. Certain vegetation types such as *Nuphar variegatum*, *Potamogeton praelongus* and *Potamogeton natans* are positively correlated with pike abundance.
10. The very large pike are distributed only in the prime habitat areas where vegetation diversity is greatest.
11. Pike growth is based upon the following factors:
    - (a.) low pike production,
    - (b.) certain vegetative types and their associations yielding adequate habitat for large pike.
    - (c.) a whitefish population which is available, appropriate, abundant and desirable as the major food item for large pike.

12. With the large numbers of pike being released it seems necessary to avoid unnecessary mortality. Restriction of the use of gaphs, bait and barbed hooks is suggested.

13. To maintain the present population size of trophy pike, a maximum of 660 fish seven years of age and older may be taken but half this number should be females. The rate of exploitation of the various age classes should not be greater than .21 at age seven, .33 at age eight, .45 at age nine and .50 in the older age groups.

14. It is indicated in this study that the structure and characteristics of the lake whitefish, walleye and northern pike populations are interdependent. Excessive alteration of any of these fish populations would affect the other populations.

LITERATURE REVIEWED

Armstrong, R. H. and R. F. Blackett, 1966. Use and evaluation of dart tags to study the migration habits of Dolly Varden, *Salvelinus malma* (Walb). Trans. Am. Fish. Soc. 95:320-323.

Assman, A. V. 1962. Consumption of the normal foods of the carp under various conditions of nutrition and population density. Trudy Inst. Morfol. Zlivotn. Akad. Nauk SSSR, No. 42.

Baranov, F. 1925. The fishing industry and the age limit among fishes. Byulleten Rybnogo Khozyaistva, No. 9. p. 26-27.

Barsokov, V. 1962. Replacement of teeth in fish. Rybovodstvoi Rybolovstvo 4. 25-28, Biol: Abs. 42 #21621.

Bennett, G. W. 1971. Management of lakes and ponds. Van Nostrand Reinhold Ltd. 375 p.

Beukema, J. J. 1970. Acquired hook avoidance in the pike, *Esox lucius* L. fished with artificial and natural baits. J. Fish. Biol. 2 (2) : 155-160.

Beverton, R. J. H. and S. J. Holt, 1957. On the dynamics of exploited fish populations. H. M. Stationery Office, London. 533 pp.

Beyerle, G. B. and J. E. Williams, 1968. Some observations of food selectivity by northern pike in aquaria. Trans. Am. Fish. Soc. 97 (1) : 28-31.

Bidgood, B. F. 1967. Ecology of walleyes, *Stizostedion vitreum vitreum* in Richardson Lake - Lake Athabasca. Alta., Dept. Lands and Forests Publ. 21 pp.

_____, 1972. Divergent growth in lake whitefish populations from two eutrophic Alberta Lakes. PHD Thesis, University of Alberta, Dept. of Zoology. 120 pp.

Bird, C. D. 1968. Key to the aquatic molluscs found in the prairies and parklands of central Alberta. Dept. Biol. University Calgary. 5 pp.

Bishop, F. 1971. A report on the trophy lake questionaire 1970-71 Alta. Fish and Wildlife Div., unpubl. report. 11 pp.

Briuzgin, V. L. 1963. Methods of studying the growth of fish from their scales, bones and otoliths. Voprosy Ikhtiologii, 3 (2) : 347-365.

Brown, E. H. and C. F. Clark 1965. Length-weight relationship of northern pike, *Esox lucius*, from East-Harbour, Ohio. Trans. Am. Fish. Soc. 94(4) : 404-5.

Bryan, J. E. 1967. Northern pike production in Phalen Pond, Minnesota. Jour. of the Minn. Acad. of Sci. Vol. 34, No. 2.

Brynildson, C., D. B. Ives and H. S. Druckenmiller 1970. A two year creel census of Devils Lake, Sauk Country. Management report No. 35 Department of Natrual Resources, Wisconsin. 11pp.

Buss, K. 1961. The northern pike. Special purpose rep. Pennsylvania Fish Commission. 58 pp.

Calhoun, A. 1966. Inland Fisheries Management. The Resources Agency Dept. of Fish and Game, California. 546 pp.

Carbine, W. F. 1942. Egg production of the northern pike, *Esox lucius* L. and the percentage survival of the eggs and young on the spawning grounds. Papers Mich. Acad. Sci., Arts. Lett., 29 : 123-137.

_____, 1942. Observations on the early history of northern pike, *Esox lucius* L. in Houghton Lake, Michigan. Trans. Am. Fish. Soc., 71: 149-164.

Carbine, W. F. and V. C. Applegate 1948. The movement and growth of marked northern pike, *Esox lucius* L., in Houghton Lake and the Muskegon River. Papers Mich. Acad. Sci., Arts, Lett. 32: 215-238.

Carlander, K. D. 1953. Handbook of freshwater fishery biology with the first supplement. Wm. C. Brown Co., Bubuque, Iowa. 429 pp.

_____, 1955. The standing crop of fish in lakes. J. Fish Res. Bd. Can. 12: 543-570.

Clark, C. F. 1950. Observations on the spawning habits of the northern pike, *Esox lucius* L., in northwestern Ohio. Copeia, 1950: 285-288.

Davis, W. S. 1964. Graphic representation of confidence intervals for Petersen population estimates. Trans. Am. Fish Soc. 93(3) : 227-232.

Demchenko, I. F. 1963. On sexual difference in the pike. Vopr: Ikhtiel 3(1) 190-193 Biol. Abs. 43(4) #16910.

Domanevski, L. N. 1963. A method for computing the numbers of pike in the Tsimlyan Reservoir. Vopr. Ikhtiol 2(3) 515-521; Biol. Abs. 45(21) #89705.

Elrod, J. H. and T. J. Hassler, 1969. Estimates of some vital statistics of northern pike, walleye and sauger populations in Lake Sharpe, South Dakota. Tech. Pap. Bureau Sport Fish and Wildlife #30.

Fabricius, E. 1950. Heterogeneous stimulus summation in the release of spawing activities in fish. Fish Bd. Sweden Inst. Freshwater Res., Drottningholm, 29: 57-99.

Fabricius, E. and K. J. Gustafson 1958. Some new observations on the spawning behaviour of the pike, *Esox lucius* L. Fish Bd. Sweden Inst. Freshwater Res., Drottningholm, 39: 23-54.

Fassett, N. C. 1960. A Manual of Aquatic Plants. The University of Wisconsin Press, Madison. 405 pp.

Finke, A. H. 1965. Northern pike tagging study Black River, La Crosse County, Wisconsin. Management Report No. 7. Wisconsin. 5 pp.

Forney, J. L. 19[illegible]. Production of young northern pike in a regulated marsh. [illegible] York Fish and Game Journal, Vol. 15, No. 2. July [illegible]

Franklin, D. R. and L. L. Smith 1963. Early life history of the northern pike with special reference to factors influencing the numerical strength of year classes. Trans. Am. Fish. Soc. April 1963 Vol. 92 No. 2.

Frost, W. E. 1954. The food of pike, *Esox lucius* L., in Windermere. J. Animal Ecol. 23: 339-60.

Frost, W. E. and C. Kipling, 1959. The determination of the age and growth of pike, *Esox lucius* L., from scales and opercular bones. J. Cons. perm. int. Explor. Mer., 24: 314-41.

_____, 1967. A study of reproduction, early-life, weight-length relationship and growth of pike, *Esox lucius* L., in Windermere. FAO Synospsis No. 30: 651-693.

Gerking, S. D. 1959. The restricted movement of fish populations. Biol. Rev. 34: 221-42.

Halver, J. E. 1972. Fish Nutrition. Academic Press New York and London. 435 pp.

Hardisty, M. W. 1954. Sex ratio in spawning population of *Lampetra planeri*. Nature 173, 874.

Hassler, T. J. 1969. Biology of the northern pike in Oahe Reservoir 1959 through 1965. Tech. Paper Bureau Sport Fish and Wildlife No. 29.

Hayes, F. R. 1957. On the variation in bottom fauna and fish yield in relation to trophic level and lake dimensions. J. Fish. Res. Bd. Can. 14: 1-32.

Hayes, F. R. and E. H. Anthony. 1964. Production capacity of North American lakes as related to the quanity and trophic level of fish, lake dimensions and water chemistry. Trans. Am. Fish. Soc. 93: 53-57.

Healy, A. 1956. *Esox lucius* L. in three Irish lakes. Scient. Proc. R. Dubl. Soc. 27: 51-63.

Hiner, L. E. 1961. Propagation of northern pike. Trans. Am. Fish. Soc. 90(3) : 298-302.

Holcik, J. 1968. Life history of the pike, *Esox lucius* L. in Klicava Reservoir. Vestn. Cesk. Spolecnosti Zool. 32(2) : 166-180, Biol. Abs. 50 #6224.

Hoogland, R. D. Morris, and N. Tinbergen. 1956. The spines of sticklebacks *(Gasterosteus and Pygosteus)* as means of defence against predators (*Perca* and *Esox*). Behavior 10(3) 205-236.

Hotchkiss, N. 1967. Underwater and Floating-Leaved Plants of the United States and Canada. Resource Publication 44. Washington D. C. 124 pp.

Hunt, R. L. 1965. Food of northern pike in a Wisconsin trout steam. Trans. Am. Fish. Soc. 94(1) : 95-96.

Hutchinson, G. E. 1957. A treatise on limnology, Vol. 2. Introduction to lake biology and the limnoplankton. John Wiley, New York 1115 pp.

Johnson, L. 1966. Experimental determination of food consumption of pike, *Esox lucius*, for growth and maintenance. J. Fish. Res. Bd. Can. 23(10) 1495-1505.

Johnson, L. D. 1971. Growth of known-age muskellunge in Wisconsin and validation of age and growth determination methods. Tech. Bulletin No. 49 Dept. Nat. Resources, Wisconsin. 24 pp.

Karakotsky, E. D. 1968. Theoretical basis of the explortation of a fish stock. Rybnoe Khozyaistvo, Vol. 44. No. 7. 22-25.

Kawanabe, H. 1958. On the significance of the social structure for the mode of density in a salmon-life fish. Ayu Plecoglossus altivelis Temminck et Schlegel. Mem. Coll. Sci. University Kyoto, Ser. B., 25 No. 3.

Kennedy, W. A. 1963. Growth and mortality of whitefish in three unexploited lakes in northern Canada. J. Fish. Res. Bd. Can. 20(2) : 265-272.

Kipling, C. and W. E. Frost. 1970. A study of the mortality, population numbers, year class strengths, production and food consumption of pike in Windermere 1944-62. J. Anim. Ecol. 39(1) : 115-157.

Kleinert, S. J. 1970. Production of northern pike in a managed marsh Lake Ripley, Wisconsin. Research Report 49. Dept. of Natural Resources, Wisconsin. 19 pp.

Koshinsky, C. D. 1972. An evaluation of two tags with northern pike, *Esox lucius* L., J. Fish. Res. Bd. Can. Vol. 29 : 469-476.

_____, 1972. The ecology, dynamics and exploitation management of northern pike at Lac La Ronge, Saskatchewan. Sask. Fish. Lab. Department Natural Resources M. S. Rep. 24 pp.

Kudrinskaya, O. T. 1969. Metabolic rate in pike, perch, golden shiner and roach larvae. Gidrobiol. Zh. 5(4) : 117-121 : Biol. Abs. 51(17) #96772.

Larsen, K. 1951. Geddens stilling i det dansk fisheri. Sportsfisseren, 20(6) : 97-9.

Lawler, G. H. 1965. The food of the pike, *Esox lucius* L., in Heming Lake, Manitoba. J. Fish. Res. Bd. Can. 22(6): 1357-1377.

_____, 1969. Activity periods of some fishes Heming Lake. J. Fish. Res. Bd. Can. 26(12) : 3266-3269.

Lawler, G. H. and G. F. M. Smith. 1963. Coloured tags in fish population estimates. J. Fish. Res. Bd. Can. 20 : 1431-1434.

Lindsay, J. D., S. Pawluk and W. Odynsky. 1963. Exploratory soil survey of Alberta map sheets 74-M, 74-L, 74-E and 73-L (north half). Res. Council of Alberta. Preliminary Soil Survey Report 63-1

McCann, J. A. and K. D. Carlander. 1970. Mark and recovery estimates of fish populations in Clear Lake, Iowa. Iowa State J. Sci. 44(3) : 369-403.

McDonald. 1964. Lake Survey Report, Seibert Lake, Alberta Fish and Wildlife Division, Dept of Lands and Forests. Unpublished Report. 6 pp.

_____, 1966. Lake Survey Report, Moose Lake. Alberta Fish and Wildlife Division, Unpublished Report 19 pp.

_____, 1967. Lake Survey Report: Winefred Lake. Alberta Fish and Wildlife Division, Unpublished Report 18 pp.

_____, 1969. Post tagging mortality of pike, perch, walleye and rainbow trout following dart tag application. Management Report No. 7: 11 pp.

McNamara, F. 1937. Breeding and food habits of the pikes, *Esox lucius* and *Esox vermiculatus*, Trans. Am. Fish. Soc. 66 : 372-373.

McPhail, J. D. and C. C. Lindsay. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173, 381 pp.

Miller, R. B. 1947. The effects of different intensities of fishing on the whitefish populations of two Alberta Lakes. J. Wildlife Mgt. 11(4) : 289-301.

_____, 1948. Anote on the movement of the pike, *Esox lucius*, Copeia 1948 : 62 pp.

Miller, R. B. and W. A. Kennedy. 1948. Pike, *Esox lucius*, from four northern Canadian Lakes. J. Fish. Res. Bd. Can. 7(4) : 190-199.

Moore, W. G. 1941. Studies on the feeding habits of fishes. Ecology 22 : 91-96.

Moss, E. H. 1959. Flora of Alberta. University Toronto Press. 381 pp.

Niemuth, Wallace, W. Churchill and T. Wirth. 1959. The walleye, its life history, ecology and management. Wisconsin Conserv. Dept. Pub. No. 227 : 14 pp.

Nikolskii, G. V. 1953. Concerning the biological basis of the rate of exploitation, and means of managing the abundance of fish stocks. Ocherki po Obshchim Oprosam Ikhtiologii. 306-318.

_____, Therory of fish population dynamics as the biological background for rational exploitation and management fishery resources. Translation J. E. S. Bradley. Oliver and Boyd Edinburgh 1969.

Northcote, T. G. and P. A. Larkin. 1956. Indices of productivity in British Columbia lakes. J. Fish. Res. Bd. Can. 13(4) : 515-540.

Paetz, M. J. 1972. A study of hybridization between two species of coregoine fishes, *Coregonus clupeaformis* and *C. artedii*, in Alberta. PHD Thesis. University of Alberta, Edmonton 127 pp.

Paetz, M. J. and J. S. Nelson. 1970. The Fishes of Alberta. The Queen's Printer, Edmonton. 282 pp.

Parker, R. R. and P. A. Larkin. 1959. A concept of growth in fishes. J. Fish. Res. Bd. Can., 16, No. 5.

Paterson, R. J. 1968. The lake trout, *Salvelinus namaycush*, of Swan Lake Alberta. M.Sc. Thesis. University of Alberta, Edmonton. 149 pp.

Pennak, R. W. 1953. Freshwater invertebrates of the United States. Ronald Press Co., New York. 769 pp.

Pinsent, M. E. 1967. Limnology of Lac La Biche and Beaver Lakes. M. Sc. Thesis, Dept. of Zoology. Univ. of Alberta. 148 pp.

Popova, O. A. 1965. The ecology of pike and perch in the Volga Delta. In: the food of predacious fishes and their relationships with their food organisms. Nauka: Moscow 91-172 : Ref. Zh. Biol. 1966 #611222. Translation: Bio. Abs. 48(19) #94400.

Prescott, G. W. 1969. The Aquatic Plants. Wm. C. Brown Co. Publishers, Dubuque, Iowa. 171 pp.

Qadri, S. U. 1961. Food and distribution of lake whitefish in Lac La Ronge, Saskatchewan. Trans. Am. Fish. Soc. 90(3) 303-327.

Rawson, D. S. 1932. The pike of Waskesiu Lake, Saskatchewan. Trans. Am. Fish. Soc. 62 : 323-330.

_____, 1957. The life history and ecology of the yellow walleye *Stizostedion vitreum* in Lac La Ronge, Saskatchewan. Trans. Am. Fish. Soc. 86 : 15-37.

Ricker, W. E. 1958. Handbook of Computations for Biological Statistics of Fish Populations. Fish. Res. Bd. Can. Ottawa Bull. No. 119. 300 pp.

_____, 1971. Methods for the assessment of fish production in freshwaters. IBP Handbook No. 3 Blackwell Scientific Publications Oxford and Edinburgh. 348 pp.

Robertson, M. R. 1967. Certain limnological characteristics of the La Biche and Wanadering Rivers. M.Sc. Thesis, University of Alberta, Edmonton Alberta. 74 pp.

_____, 1969. An investigation of a spawning population of northern pike from Floatingstone Lake, Alberta. Res. Report No. 5. 57 pp.

Robson, D. S. and H. A. Regier. 1964. Sample size in the Peterson mark recapture experiments. Trans. Am. Fish. Soc. 93(3) : 215-226.

Rounsefell, G. A. and W. H. Everhart. 1960. Fishery science its methods and applications. John Wiley, New York. 440 pp.

Ryder, R. A. 1965. A method for estimating the potential fish production of north-temperate lakes. Trans. Am. Fish. Soc. 94(3) 214-218.

Schmitz, W. R. 1953. Observations of the northern pike in Lake Mendota 1952. University of Wis. special report submitted in lieu of Master's thesis.

Schultz, F. H. 1953. Investigation of the spawning of northern pike in Prince Albert National Park, Saskatchewan. Wildlife Management Bull. Series 3 No. 4. 21pp.

Shentyakova, L. F. 1962. The Rosa Lee effect. Vopr Ikhtiol., No. 3(24)

Shkorbatov, G. L. 1954. Some ecologico-physiological characteristics of whitefishes acclimatized in waters of eastern Ukraine. Zoologic Zhurnal 33(6) : 1325-1335.

Snow, H. E. 1958. Northern pike at Murphy Flowage Wis. Conservation Bull. 23(2) : 1-4.

Snow, H. E. and T. D. Beard. 1972. A ten-year study of native northern pike in Bucks Lake, Wisconsin. Tech. Bull. No. 56. Dept. of Nat. Res. Wisconsin.

Solman, V. F. F. 1945. The ecological relations of pike, *Esox lucius* L., and waterfowl. Ecology 26 : 157-70.

Suetov, S. V. 1939. Fish productivity. Part 8. Significance of the mud layer in the use of natural food. Trudy Limnol. Stantsii v Kosine, No. 22.

Threinen, C. W. 1969. An evaluation of the effect and extent of habitat loss on northern pike populations and means of prevention of losses. Manag. Report No. 28. Wisconsin Dept. of Nat. Res.

Threinen, C. W., C. Wistrom, B. Apelgren and H. Snow. 1966. The northern pike, its life history, ecology and management. Publication No. 235. Wisconsin Conserv. Dept. 16 pp.

Tiurin, P. V. 1962. The natural mortality factor and its importance in regulating fisheries. Voprosy Ikhtiologii, Vol. 2, No. 3, 403-427.

Turner, W. R. 1967. Preliminary biological survey of Wabasca Lakes area. Survey Report No. 2. Alberta Fish and Wildlife Division 28 pp.

Toner, E. D. 1966. Synopsis of biological data on the pike, *Esox lucius* Linnaeus 1758. FAO Fisheries Synopsis No. 30. FAO of the U. N. 39 pp.

Van Engel, W. A. 1940. The rate of growth of northern pike, *Esox ludius* L. in Wisconsin waters. Copeia 1940 (3) : 177-188.

Vasentsov, V. V. 1947. Fish growth as adaptation. Byull. Mosk. Obshch. Ispyt. Pridrody, 52, No. 1.

Ward, H. B. and G. C. Whipple, 1963. Freshwater Biology. 2nd Ed. Edmundson (Ed) John Wiley, New York. 1248 pp.

Watson, W. H. F. 1963. Summer food of lake whitefish, *Coregonus clupeaformis* Mitchill from Heming Lake, Manitoba. J. Fish. Res. Bd. Can. 20(2) : 279-286.

Weatherley, A. H. 1972. Growth and Ecology of Fish Populations. Acadamic Press London, New York. 293 pp.

Welch, P. S. 1948. Limnological methods. McCraw-Hill, Toronto. 381 pp.

Zamakhaev, D. F. 1964. Effects of growth in the first years of life on the subsequent growth of fish. Trudy VNIRO, 50.

Zhakov, L. A. 1964. The effect of the abundance of perch and pike on the survival of whitefish introduced into lakes. In: Biological basis of the inland fisheries of the Baltic region Nauk. tekh. Minsk. 31-38; Biol. Abs. 47 #110605.

APPENDIX 1

DATE	ANGLERS IN PARTY	RESIDENCE	HOURS ANGLING	AM MID PM	METHODS	NO. & TYPE OF FISH KEPT	NO. OF FISH RELEASED	NO. OF FISH SAMPLED	TAGGED FISH	ANGLING LOCATION DEPTH	COMMENTS

APPENDIX II (A)

Dear Trophy Angler,

The Alberta Fish and Wildlife Division is attempting to evaluate trophy angling in this province. The following lakes have been termed Trophy Lakes due to their characteristic large fish: God's, May, Seibert, Andrew, Gardiner, Namur and Winefred.

You have purchased a licence and we wish to determine where you have fished in the past year. The specific questionnaire may be answered by all trophy anglers but for those angling at Seibert Lake we ask a few more questions.

We thank you for your cooperation and prompt return of the completed questionnaire. Enclosed is a stamped self-addressed envelope.

Sincerely,

Encl.

APPENDIX II (B)

QUESTIONNAIRE TO TROPHY ANGLERS

1. Which Trophy Lakes did you fish this year (April 1971 to March 1972)?

_____

_____

2. How many times did you fish each lake this past year?

_____

IF YOU HAVE FISHED SEIBERT LAKE IN THE LAST YEAR, PLEASE ANSWER THE FOLLOWING QUESTIONS:

3. How many times did you fish Seibert Lake in 1971-72? _____

How many times in the Winter (ice fishing) _____

Spring (May-June) _____

Summer (July-August) _____

Fall (Sept.-Oct.) _____

4. How many trophy pike (jackfish) did you catch and keep? _____

5. Did you catch any tagged pike (jackfish)? _____

6. Did you purchase a trophy licence last year (1970-71)? _____

7. Are you planning to purchase a trophy licence in the coming year (1972-73)? _____

Comments

Name _____

APPENDIX III A

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
July 6	1	A0 1943	550	5	S13
July 8	2	A0 1966	480	3	S10
	3	1949	500	3	S 8
	4	1946	485	3	S 2
	5	1944	485	3	S 2
	6	1907	625	5	S 2
July 10	7	A0 1968	609	5	S 2-S 3
	8	1965	390	2	S13
	9	1942	500	4	S13
	10	1999	380	2	S13
	11	1967	355	2	S13
	12	1963	520	6	S13
	13	1989	350	2	S13
	14	1940	395	2	S13
	15	1980	368	2	S13
	16	1978	355	2	S13
	17	1973	520	5	S13
	18	1993	455	4	S13
	19	1905	580	5	S13
	20	1951	375	2	S13
	21	1958	452	3	S13
	22	A0 1962	600	6	S13
	23	1903	357	2	S13
	24	1923	375	2	S13

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	25	1992	357	2	S13
	26	1939	385	2	S13
	27	1912	522	4	S13
	28	1904	690	6	S13
	29	1913	550	5	S13
July 11	30	A0 1974	630	5	S 2-S 3
July 12	31	A0 1937	530	4	S 5
	32	1910	620	5	S 5
	33	1933	475	5	S 4
July 13	34	A0 1981	400	2	S 3
	35	1957	450	4	S 3
	36	1961	510	4	S 3
	37	1945	475	3	S 3
July 14	38	A0 1930	540	3	S 9
	39	1902	490	3	S 9
	40	1924	530	3	S 6-S 7
	41	1915	510	3	S 3
	42	1920	520	3	S 3
	43	1914	470	3	S 3
	44	1926	550	3	S 3
	45	1908	415	2	S 3
	46	1956	535	3	S 3
	47	1952	508	4	S 3
	48	1917	580	4	S 3

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
July 15	49	A0 1909	510	3	S 2
	50	1994	410	2	S 2
July 16	51	A0 2000	655	6	S11-S12
July 17	52	A0 1901	523	4	S 3
	53	1986	390	2	S 3
	54	1977	390	2	S 3
	55	1987	395	2	S 3
July 18	56	A0 1929	550	7	S14
	57	1988	350	2	S14
	58	1990	505	3	S 5
	59	1995	540	4	S 5
	60	1950	560	6	S 5
	61	1970	570	5	S 5
	62	1948	420	4	S 5
	63	1922	530	4	S 5
	64	1928	515	5	S 5
	65	1971	390	2	S 5
	66	1969	1050	11	S 5
	67	1953	515	5	S 5
	68	1918	522	3	S 3
	69	1982	350	2	S 3
	70	1938	480	4	S 3
	71	1935	420	4	S 3
July 19	72	A0 1998	487	3	S 9

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	73	1979	478	3	S 9-S10
	74	1960	498	3	S 9-S10
	75	1976	495	3	S 9-S10
	76	1921	494	3	S 9-S10
	77	1959	495	3	S 9-S10
	78	1925	499	3	S 9-S10
	79	1931	570	5	S 9-S10
	80	1932	470	5	S 9
	81	1926	575	4	S 9
	82	1941	480	3	S 9
	83	1906	580	4	S 9
	84	1936	455	3	S 9
	85	1916	565	4	S 9
	86	1919	570	6	S 9
	87	1927	590	4	S 9
	88	1955	570	5	S 5
July 31	89	A0 1934	600	4	S 3-S 4
	90	M00 949	505	4	S 3-S 4
	91	941	525	4	S 3-S 4
	92	928	650	6	S 2-S 3
	93	944	527	4	S13
	94	932	518	5	S13
	95	950	378	2	S13
	96	948	468	5	S13

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	97	947	524	5	S13
	98	940	515	5	S13
	99	927	540	4	S14
August 1	100	M00 938	490	4	S 5
	101	926	345	2	S 5
	102	936	532	4	S 5
	103	943	270	1	S 4-S 5
	104	939	636	6	S 5
August 2	105	M00 935	395	2	S 3
	106	934	520	4	S 2-S 3
	107	937	521	4	S 2-S 3
	108	929	500	4	S 2-S 3
	109	931	582	5	S x-S 3
	110	982	545	4	S14
	111	985	430	2	S14
	112	996	475	6	S14
	113	979	478	5	S14
	114	987	385	2	S13
	115	986	370	2	S13
	116	989	440	3	S13
August 3	117	M00 991	374	2	S13
	118	983	390	3	S13
	119	995	403	2	S12
	120	A0 1972	785	7	S12

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	121	M00 984	278	1	S 5-S 6
	122	1000	383	2	S 5
August 4	123	M00 998	360	2	S 6-S 7
	124	977	565	9	S 6-S 7
	125	988	562	5	S 6-S 7
	126	993	528	6	S 7
	127	978	535	4	S 7
	128	997	525	3	S 7
	129	990	510	4	S 7
	130	980	520	5	S 7
	131	967	500	3	S 7
	132	971	574	5	S 8
	133	956	544	5	S 8
	134	969	568	4	S 8
	135	959	474	3	S 8
	136	951	604	6	S 8
	137	972	518	4	S 8
	138	961	470	4	S 8
	139	975	373	2	S 8
	140	964	540	4	S 8
	141	973	500	4	S 8
	142	974	567	5	S 8
	143	970	638	5	S 8
	144	968	540	4	S 8

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	145	963	520	3	S 8
	146	904	510	4	S 8
	147	924	401	2	S 8
	148	921	572	3	S 8
August 5	149	M00 905	382	2	S14
	150	901	570	5	S13
	151	396	444	4	S13
	152	385	450	4	S13
	153	398	525	5	S13
	154	388	517	4	S13
	155	380	552	5	S13
	156	376	507	4	S13
	157	383	535	4	S 1
	158	387	530	3	S 1
	159	378	583	4	S 1
	160	397	463	3	S 1-S 2
August 5	161	M00 395	558	5	S 2
	162	379	702	5	S 2
	163	400	768	7	S 2
	164	377	538	4	S 2
August 6	165	M00 394	552	3	S10
	166	390	590	5	S10
	167	393	403	2	S10
	168	386	388	2	S10
	169	389	426	2	S10

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	170	391	405	2	S 9-S10
	171	908	450	3	S 2-S 3
	172	906	490	3	S 2-S 3
	173	912	514	3	S 2
	174	914	508	4	S 2
	175	913	518	3	S 2
August 7	176	M00 917	564	3	S 9
	177	923	500	3	S10
	178	902	483	4	S10
	179	919	425	2	S10
	180	925	540	5	S10
	181	278	490	4	S 9-S10
	182	284	482	4	S 9
	183	281	542	4	S 9
	184	280	580	5	S 9
	185	285	595	5	S 9
	186	399	587	4	S 9
	187	382	611	5	S 9
	188	392	614	5	S 9
	189	381	873	9	S 9
	190	384	562	6	S 9
	191	299	582	4	S 9
	192	277	573	4	S 9
	193	283	550	4	S 9
	194	297	553	3	S 9

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	195	279	600	5	S 9
	196			5	S 9
	197	238	540	5	S 9
	198	228	560	6	S 9
	199	239	488	4	S 9
	200	236	618	6	S 9
	201	235	566	5	S 9
	202	294	700	6	S 8
	203	226	541	4	S 8
	204	240	613	4	S 8
	205	234	515	3	S 8
	206	242	574	5	S 8
	207	295	530	4	S 8
	208	247	515	3	S 8
	209	300	542	6	S 8
	210	M00 229	520	4	S 5
	211	255	398	2	S 5
	212	274	358	2	S 5
	213	267	378	2	S 5
	214	251	491	5	S 5
	215	265	468	6	S 5
	216	263	398	2	S 5
	217	254	516	5	S 5
	218	264	426	5	S 5
	219	256	403	2	S 5

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	220	258	338	1	S 5
	221	257	305	1	S 5
	222	273	445	3	S 5
	223	261	373	2	S 5
	224	269	306	1	S 5
August 9	225	M00 275	402	2	S 2
August 10	226	M00 268	434	2	S 9
	227	262	566	6	S 9
	228	270	620	4	S 9
	229	266	590	4	S 9
	230	259	470	2	S 9
	231	208	578	5	S 9
	232	224	608	6	S 9
	233	222	556	4	S 9
	234	203	589	5	S 8
	235	211	535	4	S 8
	236	204	527	3	S 7-S 8
	237	210	428	3	S 7
	238	209	505	3	S 7
	239	217	504	3	S 7
	240	218	512	2	S 7
	241	286	505	3	S 7
	242	289	547	3	S 7
August 11	243	M00 276	275	1	S 5
	244	296	317	1	S 5

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	245	298	280	1	S 4
August 12	246	M00 292	368	2	S12-S13
	247	293	444	2	S12-S13
	248	288	524	5	S12-S13
	249	290	283	1	S13
	250	291	498	5	S13
	251	221	310	1	S13
	252	202	467	3	S13
	253	220	390	2	S13
	254	225	380	2	S13
	255	213	479	6	S13
	256	241	568	5	S13
	257	244	514	4	S13
	258	237	458	3	S13
	259	219	422	2	S13
August 13	260	M00 223	618	6	S 3
	261	214	550	3	S 3
	262	216	574	4	S 3
	263	205	312	1	S 3
	264	207	388	2	S 2-S 3
	265	201	509	3	S 2-S 3
	266	206	490	3	S 2
August 14	267	M00 215	559	3	S 7
	268	212	502	3	S 7
	269	253	436	2	S 7

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	270	252	610	4	S 7
	271	916	553	3	S 7
	272	903	432	3	S 7
	273	909	380	2	S 7
	274	910	595	3	S 7
	275	915	459	4	S 7
	276	911	429	3	S 8
	277	918	529	4	S 8
	278	922	535	9	S 8
	279	920	540	5	S 8
	280	907	515	5	S 8
	281	966	483	3	S 8
	282	962	672	6	S 8
	283	954	435	2	S 8
	284	969	475	3	S 8
	285	955	385	2	S 8
	286	957	547	3	S14
	287	953	485	5	S14
	288	952	503	6	S14
	289	960	302	1	S14
	290	958	562	6	S14
	291	994	372	2	S14
	292	976	556	4	S13
	293	981	582	7	S13
	294	992	433	3	S13

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	295	999	510	6	S13
	296	930	525	9	S13
	297	333	540	5	S13
	298	942	540	5	S13
	299	945	397	2	S13
	300	946	404	2	S13
	301	232	525	4	S13
August 15	302	M00 249	565	6	S 3
	303	245	452	2	S 3
	304	233	538	5	S 3
	305	250	516	3	S 3
	306	230	444	3	S 3
	307	227	550	5	S 3
	308	248	575	5	S 3
	309	246	568	4	S 3
	310	243	478	4	S 3
	311	260	605	5	S 3
	312	272	649	6	S 3
	313	271	429	2	S 3
	314	231	425	2	S 3
	315	287	529	4	S 1
	316	345	585	4	S 1
	317	342	480	3	S 1
August 16	318	M00 349	660	7	S12
October 2	319	M00 329	402	2	S13

APPENDIX III A (cont'd)

1971 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	320	333	750	7	S13
	321	339	579	5	S13
	322	327	414	2	S13
	323	347	452	2	S13
	324	341	605	4	S13
	325	346	565	4	S13

APPENDIX III B

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
May 20	1	S00 976		7	S13
	2	999		3	S13
	3	978		6	S13
	4	992		6	S13
	5	982	725	6	S 5
	6	995	610	5	S 5
	7	998	550	6	S 5
	8	989	520	5	S 5
	9	985	605	6	S13
	10	979	940	9	S13
	11	997	560	4	S14
	12	977	650	6	S14
	13	988	605	6	S14
May 27	14	S00 981	555	7	S 9
	15	986	527	4	S 9
	16	1000	560	4	S 9
	17	983	525	4	S 9
	18	993	553	5	S 9
	19	994	520	4	S 9
	20	991	775	7	S 9
	21	938	628	5	S 8
	22	942	760	7	S 8
	23	946	610	5	S 8
	24	932	360	2	S13
	25	935	415	4	S14

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
May 28	26	S00 980	685	6	S 5
	27	984	800	8	S 5
	28	990	758	6	S 5
	29	987	705	5	S 5
	30	996	680	5	S 5
	31	939	765	6	S 5
	32	936	671	5	S 5
	33	937	884	7	S 5
	34	941	620	5	S 5
	35	940	785	7	S 5
	36	930	778	6	S 5
	37	934	865	8	S 5
	38	943	682	5	S 5
	39	948	568	5	S 5
	40	910	710	7	S 5
	41	920	640	6	S 5
June 3	42	901	570	5	S 8
	43	917	615	6	S 8
	44	909	425	3	S 8
	45	921	545	5	S 8
	46	925	540	5	S 8
	47	912	495	3	S 8
	48	911	560	5	S 8
	49	923	685	8	S 5
	50	904	595	4	S 5

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	51	907	830	8	S 5
	52	919	670	6	S 5
	53	924	653	6	S 5
	54	902	725	6	S 5
	55	915	595	6	S 5
	56	913	585	7	S 5
	57	905	700	5	S 5
	58	922	525	5	S 5
	59	903	495	5	S 5
	60	914	595	6	S 5
	61	906	608	8	S 5
	62	918	588	6	S 5
	63	908	472	4	S13
	64	916	509	5	S13
	65	972	570	6	S13
	66	974	530	5	S 2
	67	973	602	5	S 2
	68	954	450	3	S 2
	69	963	450	3	S 2
	70	962	485	3	S 2
	71	967	540	7	S13
	72	952	480	5	S13
	73	956	420	3	S13
	74	960	360	2	S13
	75	958	780	6	S13

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	76	968	547	7	S13
	77	964	704	7	S13
	78	953	495	6	S14
	79	965	406	3	S14
	80	961	570	7	S14
June 10	81	S00 957	592	6	S 5
	82	955	400	3	S 5
	83	971	425	4	S 5
	84	966	508	4	S 5
	85	959	505	6	S 5
	86	951	534	6	S 5
	87	969	575	5	S 5
	88	975	507	6	S 5
	89	970	506	7	S 5
	90	466	508	6	S 5
	91	475	512	4	S 5
	92	474	546	6	S 5
	93	473	592	7	S 5
	94	874	407	3	S 5
	95	453	535	7	S 5
	96	465	685	7	S 5
	97	460	492	5	S 5
	98	455	603	5	S 5
	99	470	565	6	S 5
	100	461	578	7	S 5

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	101	451	512	4	S 5
	102	456	565	6	S 5
	103	468	490	4	S 5
	104	464	450	3	S 5
	105	452	490	4	S 5
	106	458	565	4	S 5
	107	454	490	6	S13
	108	462	455	3	S13
	109	472	545	6	S13
	110	459	508	6	S13
	111	471	480	5	S13
	112	463	410	3	S13
	113	469	567	6	S13
	114	457	435	3	S13
	115	498	415	3	S13
	116	476	470	3	S13
	117	482	442	3	S13
	118	492	502	4	S13
	119	497	393	3	S13
	120	481	530	6	S13
	121	499	595	8	S13
	122	486	497	6	S13
	123	489	515	6	S13
	124	478	520	5	S13
	125	488	540	6	S13

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	126	493	528	4	S13
	127	480	555	4	S13
	128	479	528	4	S13
	129	487	457	3	S13
	130	491	431	3	S13
	131	496	400	3	S13
	132	495	415	2	S14
	133	490	505	5	S14
June 11	134	S00 500	542	4	S 9
	135	483	455	3	S 9
	136	494	425	3	S 9
	137	477	505	4	S 9
	138	485	545	4	S 9
	139	403	490	3	S 9
	140	402	417	4	S 9
	141	423	540	4	S 9
	142	421	415	2	S 9
	143	417	557	4	S 9
	144	422	520	5	S 9
	145	406	535	3	S 9
	146	405	565	6	S 9
	147	404	465	3	S 9
	148	424	465	3	S 9
	149	407	433	3	S 9
	150	412	490	6	S10

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	151	425	550	4	S10
	152	418	533	4	S 1
June 24	153	S00 414	400	2	S 8
	154	410	494	5	S 8
	155	415	494	4	S 8
	156	419	555	4	S 8
	157	146	395	2	S 8
	158	413	554	6	S 8
	159	408	482	3	S 8
	160	401	430	3	S 8
	161	411	485	4	S 8
	162	420	628	5	S 8
	163	446	432	3	S 8
	164	430	390	2	S 8
	165	427	405	3	S 8
	166	435	460	3	S 8
	167	428	638	6	S 8
	168	441	520	5	S 8
	169	440	567	4	S 8
	170	432	410	3	S 8
	171	447	420	3	S 8
	172	444	698	6	S 8
	173	449	593	5	S 8
	174	443	455	3	S 2
	175	442	393	2	S 2

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
June 25	176	S00 426	548	4	S13
	177	445	530	4	S13
	178	436	530	4	S14
July 5	179	S00 450	535	5	S13
	180	434	497	4	S13
July 6	181	S00 431	450	3	S13
	182	429	380	2	S14
	183	438	457	4	S13
	184	437	505	7	S13
	185	433	483	3	S13
July 7	186	S00 439	582	5	S 7
	187	448	515	5	S 7
	188	856	380	2	S 8
	189	858	575	5	S 8
	190	875	445	3	S 8
	191	931	545	5	S 5
	192	950	475	4	S 5
	193	929	522	5	S 5
July 8	194	S00 927	535	4	S12
	195	926	410	2	S 2
	196	928	426	3	S 2
	197	949	557	6	S 2
	198	945	461	3	S 2
	199	944	475	4	S 2
	200	933	515	4	S 2

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
July 10	201	S00 161	533	8	S 5
	202	265	460	3	S 5
	203	263	411	2	S 5
	204	264	555	5	S 5
	205	261	594	4	S 7
	206	269	525	4	S 7
	207	268	552	5	S 7
	208	270	524	3	S 7
July 11	209	S00 255	578	6	S 3
	210	131	500	3	S 3
	211	275	556	4	S 3
	212	266	520	4	S 3
	213	267	527	4	S 3
	214	256	512	4	S 3
	215	273	515	5	S 3
	216	257	545	4	S 3
	217	252	370	2	S 3
	218	259	450	3	S 3
	219	272	410	3	S 3
July 12	220	S00 258	670	5	S10
	221	218	790	6	S10
	222	208	517	3	S10
	223	219	617	5	S10
	224	210	611	5	S10
	225	274	650	5	S10

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	226	271	500	3	S10
	227	251	620	7	S10
	228	260	590	6	S13
	229	254	410	3	S13
	230	253	650	5	S13
	231	221	514	5	S13
	232	215	502	5	S13
	233	223	570	6	S 3
	234	211	450	3	S 3
	235	206	464	3	S 3
	236	213	447	3	S 3
	237	214	450	3	S 3
	238	205	435	3	S 3
	239	224	460	3	S 3
	240	212	490	5	S 3
July 13	241	S00 202	522	4	S13
	242	207	430	3	S14
July 14	243	225	530	3	S 9
	244	216	615	5	S 9
	245	222	576	5	S 9
	246	201	530	4	S 9
	247	203	482	3	S 9
	248	209	610	4	S 9
	249	217	559	5	S 9
	250	220	591	5	S 9

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	251	297	469	3	S 9
	252	294	537	3	S 9
	253	298	825	7	S 9
	254	300	495	3	S 9
	255	282	410	2	S 9
	256	277	496	3	S 9
	257	291	534	6	S 9
	258	279	481	3	S 9
	259	278	537	5	S 9
	260	204	489	3	S 4
	261	289	385	2	S 4
	262	285	497	4	S 4
	263	292	454	4	S 3
	264	293	553	4	S 3
	265	280	609	6	S 3
	266	276	573	6	S 3
	267	295	480	4	S 3
	268	288	435	3	S 3
	269	283	580	5	S 3
	270	299	450	2	S 3
	271	230	515	3	S 3
July 15	272	S00 250	544	4	S 9
	273	246	528	5	S 9
	274	528	545	3	S 9
	275	245	424	3	S 9

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	276	287	530	5	S 9
	277	286	610	7	S 9
	278	284	535	4	S 9
	279	296	465	4	S 9
	280	239	469	5	S 9
	281	234	508	5	S 9
	282	237	515	4	S 9
	283	235	547	4	S 8
	284	228	380	2	S 8
	285	240	582	4	S 8
	286	238	538	5	S 8
	287	226	534	4	S 8
	288	242	567	4	S 8
	289	247	520	3	S 8
	290	227	393	2	S 8
	291	241	376	2	S 8
	292	248	478	3	S 8
	293	249	487	3	S 8
	294	243	464	3	S 8
	295	244	478	3	S 8
	296	233	410	2	S 8
	297	232	456	2	S 8
	298	229	416	3	S 8
	299	663	607	5	S 8
	300	664	418	3	S 8

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	301	655	539	4	S 9
August 2	302	S00 667	535	4	S 2
	303	668	514	4	S 2
	304	653	471	3	S 2
August 3	305	S00 661	397	2	S 4
	306	665	517	3	S 4
	307	658	645	5	S 3
	308	651	655	6	S 3
	309	671	396	4	S 3
	310	666	503	3	S 3
	311	674	466	3	S 3
	312	673	588	6	S 3
	313	670	522	5	S 3
	314	672	380	2	S 3
August 4	315	S00 660	660	6	S10
	316	669	769	7	S10
	317	662	740	6	S10
August 5	318	S00 657	460	2	S 2
	319	675	375	2	S 3
August 8	320	S00 654	606	6	S 1
	321	656	485	3	S 2
	322	652	415	2	S 2
August 9	323	S00 608	724	6	S 8
	324	606	512	4	S 8
	325	607	383	2	S 8

APPENDIX III B (cont'd)

1972 TAGGING

Date	Fish No.	Tag No.	Size (mm)	Age	Location
	326	624	720	6	S 8
	327	625	396	2	S 8
	328	612	370	2	S 8
	329	614	400	3	S 8
August 10	330	S00 605	830	8	S 3
August 13	331	S00 601	433	3	S 2
	332	604	600	6	S 6
	333	613	340	2	S 6
	334	609	422	3	S 7
	335	611	530	4	S 7
	336	610	388	2	S 7
	337	603	507	3	S 7
August 14	338	S00 616	642	6	S13
	339	620	597	8	S 1

APPENDIX IV

CHEMICAL ANALYSIS OF SEIBERT LAKE WATER

(Analytical report from the Division of Pollution Control Laboratory of the Alberta Department of Lands and Forests)

Date sampled July 3, 1971 Grab sample

pH	8.8
Alkalinity, PP (as $CaCO_3$)	17.5 mg/l
Total (as $CaCO_3$)	220 mg/l
Chlorides	3
Total Hardness (as $CaCO_3$)	194 mg/l
Total Residue	336 mg/l
Ignition Loss	178 mg/l
Total Suspended Solids	4 mg/l
Ignition Loss	3 mg/l

APPENDIX V

LIST OF THE GENERA OF BOTTOM FAUNA

Phylum Arthropoda

C. Crustacea

Amphipoda

Gammarus

Hyalella

C. Insecta

O. Diptera

Chaoborus

Chrysops

Palpomyia

Pentaneura

Tendipes

O. Coleoptera

Dytiscus

O. Ephemeroptera

Ephemera

Caenis

O. Hemiptera

Notonecta

O. Odonata

Lestes

Aeschna

Macromia

O. Trichoptera

Atripsodes

Heliopsyche

Molanna

Neophylax

Phryganea

Phylum Chordata

C. Ostelchthyes

Culaea

Phylum Annelida

C. Oligochaeta

C. Hirudinea

Phylum Mollusca

C. Gastropoda

Gyraulus

Valvata

Promenetus

Stagnicola

C. Pelecypoda

Pisidium

Sphaerium

APPENDIX VI

LAKE WHITEFISH: VARIATION IN FORK LENGTHS AND WEIGHTS OF AGE CLASSES

Age Classes	Sample Size ♂	♀	Total	Mean Fork Length(mm)	Standard Deviation	Mean Wet Weight(gm)	Standard Deviation	Percent of Age Classes
1+			9	194.3	15.2	119.2	11.6	9
2+			3	271.7	10.4	320.7	65.3	3
3+	6	7	13	307.9	8.6	448.7	45.4	13
4+	4	0	4	347.8	8.2	610.2	56.8	4
5+	7	7	14	356.9	41.0	698.6	82.4	14
6+	15	9	24	374.6	21.5	761.1	125.0	24
7+	5	9	14	390.4	16.2	792.4	144.8	14
8+	2	12	14	394.4	26.8	860.5	184.6	14
9+	1	4	5	400.2	21.1	897.4	173.2	5
10+								
11+								
12+	1		1	481		1504.1		1
Total	41	60	101					

APPENDIX VII

STOMACH CONTENTS OF LAKE WHITEFISH

Food Items	No. of Whitefish with Items	Percent of Total	Percent Occurrence	Total No. Items	Average No. per Fish
Amphipoda	27	28	61.4	592	21.9
Ephemeroptera	11	11	25.0	745	67.7
Trichoptera	9	9	20.5	110	12.2
Diptera	15	15	34.1	468	31.2
Hemiptera	4	4	9.0	8	2.0
Odonata	1	1	2.3	1	1.0
Coleoptera	2	2	4.5	4	2.0
Hirudinea	11	11	25.0	105	9.5
Oligochaeta	2	2	4.5	3	1.5
Mollusca	16	16	36.4	216	13.5
Osteichthyes	4	4	9.0	8	2.0
Total with Food	44	45			51.4
Empty	54	55			

APPENDIX VIII

WALLEYE: VARIATION IN FORK LENGTHS (mm)

Age Classes	Immatures n	Immatures Fork Length	Immatures S	Immatures $S_{\bar{x}}$	Males n	Males Fork Length	Males S	Males $S_{\bar{x}}$	Females n	Females Fork Length	Females S	Females $S_{\bar{x}}$	Combined n	Combined Fork Length	Combined S	Combined $S_{\bar{x}}$
0+	6	55.0														
1+																
2+																
3+	2	298.5											2	298.5		
4+	25	336.9	12.8	2.6									25	336.9	12.8	2.6
5+	55	365.8	13.2	1.8	78	364.3	14.2	1.6	57	369.4	17.6	2.3	190	366.3	15.1	1.1
6+	21	394.6	15.3	3.3	227	391.1	15.9	1.1	178	411.6	21.4	1.6	426	399.8	20.9	1.0
7+					107	412.7	21.0	2.0	244	442.0	26.2	1.7	351	433.1	28.1	1.5
8+					15	430.7	25.0	6.4	41	497.0	33.2	5.2	56	479.2	43.2	5.8
9+									22	521.3	36.2	7.2	22	521.3	36.2	7.2
10+									2	554.5			2	554.5		

APPENDIX IX

WALLEYE: VARIATION IN WEIGHTS (grams)

Age Classes	Immatures n	Immatures Mean Weight	Immatures S	Immatures $S_{\bar{x}}$	Males n	Males Mean Weight	Males S	Males $S_{\bar{x}}$	Females n	Females Mean Weight	Females S	Females $S_{\bar{x}}$	Combined n	Combined Mean Weight	Combined S	Combined $S_{\bar{x}}$
0+																
1+																
2+																
3+	2	255.0											2	255.2		
4+	25	399.6	41.4	7.9									25	399.2	41.4	7.9
5+	55	517.9	57.0	7.4	78	500.9	54.2	5.7	57	538.1	67.5	8.5	190	516.5	61.1	4.0
6+	21	636.3	73.5	15.9	227	609.8	74.3	4.8	178	729.4	103.6	7.4	426	660.6	105.1	4.8
7+					107	717.4	109.3	10.2	244	895.7	158.4	9.6	351	840.6	166.7	8.5
8+					15	798.3	149.0	38.3	41	1252.7	230.7	35.8	56	1130.3	295.1	39.2
9+									22	1353.2	330.6	70.4	22	1353.2	330.6	70.4
10+									2	1560.9			2	1560.9		

APPENDIX X

WALLEYE STOMACH CONTENTS

Food Items	Number of Stomachs	Percent of all Stomachs	Percent Occurrence	Total number of Items	Mean Number of Items	Percent of Total Items
Osteichthyes						
Culaea inconstans	28	2.9	9.6	364	13.0	7.9
Stizostedion vitreum	9	1.0	3.1			
Coregonus clupeaformis	5	0.5	1.7			
Perca flavescens	4	0.4	1.4			
Notropis hudsonius	3	0.3	1.0	179	1.9	3.9
Lota lota	3	0.3	1.0			
Pimephales promelas	1	0.1	0.3			
Unidentifiables	71	7.3	24.3			
Amphipoda	172	17.8	58.9	3248	18.9	70.7
Hyalella, Gammarus						
Hirudinea	33	3.4	11.3	60	1.8	1.3
Ephemeroptera	85	8.8	29.1	373	4.4	8.1
Ephemera						
Ephemeroptera	14	1.4	4.8	77	5.5	1.7
Caenis						
Odonata	65	6.7	22.3	210	3.2	3.6
Lestes, Macromia Aeschna						

APPENDIX X (cont'd)

WALLEYE STOMACH CONTENTS

Food Items	Number of Stomachs	Percent of all Stomachs	Percent Occurrence	Total Number of Items	Mean Number of Items	Percent of Total Items
Trichoptera	39	4.0	13.4	64	1.6	1.4
Phryganea, Molanna						
Hemiptera	5	0.5	1.7	5	1.0	0.1
Notonecta						
Diptera	5	0.5	1.7	6	1.2	0.1
Tendipes						
Coleoptera	5	0.5	1.7	10	2.0	0.2
Dytiscus						
Total with food	292	30.2			15.7	
Empty	675					

APPENDIX XI

NORTHERN PIKE: VARIATION IN FORK LENGTHS (mm)

Age Classes	Males n	Males Mean Lengths	Males S	Males $S\bar{x}$	Females n	Females Mean Lengths	Females S	Females $S\bar{x}$	Unidentified n	Unidentified Mean Lengths	Unidentified S	Unidentified $S\bar{x}$
0+									7	116.7		
1+									16	293.6	27.9	7.0
2+									8	386.3	27.5	9.7
3+	10	480.8	42.8	13.5	27	514.3	57.7	14.4				
4+	26	515.1	37.0	7.3	25	536.7	33.3	6.7				
5+	37	555.1	39.7	6.5	38	620.8	54.6	8.9				
6+	34	582.9	62.1	10.6	35	704.3	50.4	8.5				
7+	15	651.0	57.7	14.9	96	779.2	46.5	4.7				
8+	15	745.6	68.2	17.6	87	849.7	51.7	5.5				
9+	6	730.5	59.7	24.4	45	938.8	64.3	9.6				
10+	4	715.3	87.9	44.0	24	1002.0	55.6	11.4				
11+	3	882.3	51.3	29.6	5	961.2	86.9	38.9				
12+	1	785										
13+	2	903.5			1	1010						
14+	1	955										

APPENDIX XII

NORTHERN PIKE: VARIATION IN WEIGHTS (grams)

Age Classes	Males				Females				Unidentified (Immature)			
	n	Mean Weights	S	$S_{\bar{x}}$	n	Mean Weights	S	$S_{\bar{x}}$	n	Mean Weights	S	$S_{\bar{x}}$
0+												
1+												
2+									8	422.9	72.9	25.5
3+	10	740.7	171.4	53.9	27	894.0	268.8	67.0				
4+	26	868.7	183.1	35.8	25	976.3	177.1	35.2				
5+	37	1043.8	236.4	38.6	38	1692.9	632.0	102.5				
6+	34	1340.7	534.1	91.4	35	2638.5	697.3	117.8				
7+	15	2007.3	857.4	221.4	96	3659.6	756.3	77.2				
8+	15	2960.0	740.7	191.3	87	4952.9	952.4	101.9				
9+	6	1894.8	914.4	373.2	45	6596.6	1406.5	208.9				
10+	4	2838.0	995.9	497.8	24	8149.6	1337.8	273.0				
11+	3	4654.3	563.6	316.7	5	7060.9	1720.7	769.4				
12+	1	3746.2										
13+	2	6186.8			1	7719.4						
14+	1	6130.1										

APPENDIX XIII

PIKE CAUGHT 1971 and 1972

Lake Zone	Number of Pike Released	Number of Pike Retained	Total Number Caught	Percent Released	Percent Retained	Percent of Total Caught
S 1	34	8	42	1.5	1.3	1.5
S 2	28	9	37	1.2	1.5	1.3
S 3	74	27	101	3.3	4.4	3.5
S 4	9	2	11	0.4	0.3	0.4
S 5	728	153	881	32.1	25.1	30.6
S 6	2	3	5	0.1	0.5	0.2
S 7	92	19	111	4.1	3.1	3.9
S 8	229	54	283	10.1	8.9	9.8
S 9	254	68	322	11.2	11.1	11.2
S10	56	8	64	2.5	1.3	2.2
S11	2	0	2	0.1	0	0.04
S12	12	0	12	0.5	0	0.4
S13	693	234	927	30.6	38.4	32.2
S14	53	25	78	2.3	4.1	2.7
Total	2266	610	2876			

APPENDIX XIV

VARIATION IN FORK LENGTH OF TAGGED PIKE

Age Class	Sample Size	Percent Number of Total	Mean Length (mm)	Standard Deviation	Standard Error about the Mean
0+					
1+	16	2.4	293.6	27.9	7.0
2+	99	15.0	395.0	29.7	3.0
3+	153	23.1	476.5	43.4	3.5
4+	143	21.6	524.7	43.4	3.6
5+	125	18.9	560.4	54.5	4.9
6+	84	12.7	599.6	78.9	8.6
7+	27	4.1	656.9	110.5	21.3
8+	9	1.4	704.8	127.0	42.3
9+	5	0.8	687.6	201.8	90.2
10+					
11+	1	0.2	1050		

APPENDIX XV

LIST OF BOTTOM FAUNA FOUND AT THE 10 FT (3.0 M) DEPTH

Phylum Arthropoda

C. Arachnida

Hydracarina

C. Crustacea

Amphipoda

Gammarus

Hyalella

C. Insecta

Diptera

Tendipes

Tabanus

Pentaneura

Palpomyia

Ephemeroptera

Caenis

Ephemera

Hemiptera

Notonecta

Odonata

Macromia

Aeschna

Lestes

Trichoptera

Heliopsyche

Molanna

Phryganea

Phylum Platyhelminthes

Planaria

Phylum Osteichthyes

Etheostoma exile

Phylum Annelida

Oligochaeta

Hirudinea

Phylum Mollusca

Gastropoda

Helisoma

Gyraulus

Physa

Promenetus

Stagnicola

Valvata

Pelecypoda

Pisidium

Sphaerium